

GEOLOGY OF THE WEST TINTIC RANGE AND VICINITY

TOOELE AND JUAB COUNTIES, UTAH

by

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A thesis submitted to the faculty of the University  
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the degree

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This Thesis for the Ph.D. degree


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# GEOLOGY OF THE WEST TINTIC RANGE AND VICINITY

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## ABSTRACT

The area discussed comprises approximately 200 square miles and includes the West Tintic Range and part of the Sheeprock Range. The area is near the eastern boundaries of Tooele and Juab Counties, Utah, and is less than ten miles west of the Tintic mining district. Utah Highway 36 forms the northern boundary, and the Jerico Road forms the southern boundary. The eastern and western boundaries are defined by longitudes  $112^{\circ} 15'$  and  $112^{\circ} 25' 15''$  West respectively.

Sedimentary and metasedimentary rocks exposed within the area, include from older to younger: at least 13,000 feet of Precambrian schist, banded and unbanded phyllite, tillite, quartzite, argillite, and conglomerate of the Sheeprock series, and the Mutual(?) formation; at least 11,500 feet of Paleozoic carbonates and clastics which represent parts of all periods except the Permian; Tertiary strata, thought to represent all of the Tertiary epochs, and possibly being several thousand feet in thickness; several hundred feet of Pleistocene pediment gravels, recent alluvium and aeolian deposits. Mesozoic sediments, with the possible exception of an unnamed greenstone, are absent from the area.

Igneous rocks include the West Tintic monzonite intrusive and a younger granite intrusive. Extrusive rocks are abundant in the area and include from the oldest to the youngest: a diabasic rock, which may represent a Precambrian flow; a rhyolite sequence, tentatively correlated with the Packard latite of the East Tintic Range; an andesite and agglomerate sequence which unconformably overlies the granite is intercalated with beds of known mid-Eocene Green River age, and is correlated with the latite and agglomerate sequence of the East Tintic Range; a few remnants of basalt flows, probably of late Tertiary or early Quaternary age.

Three orogenic episodes are recognized and attributed to Cretaceous, earliest Tertiary, and later Tertiary phases of deformation. These episodes are tentatively considered to

correlate in time with the Cedar Hills, Laramide, and Basin and Range orogenies which are more specifically recognized in nearby areas. More precise dating of pre-Tertiary deformation is not possible because of the absence of Mesozoic sediments critical to such dating. Structures considered contemporaneous with the Cedar Hills orogeny include the West Tintic anticline, the Brown's Ridge homocline, and the monocline north of Little Valley. Structures assigned to the Laramide orogeny include the Sheeprock thrust system and recumbent folds and tear faults in the allochthon. The Basin and Range structural features consist of range-defining high-angle faults such as the Vernon Creek fault and flexures and folds in the Green River-Salt Lake strata.

The West Tintic and Blue Bells mining districts are in the Sheeprock portion of the area. The West Tintic district has a history of sporadic production since 1870, with production of minor amounts of gold, silver, lead, copper, tungsten, and iron ores. Nearly all production came from the Scotia mine. At present (1957), there is no mining activity in the West Tintic district. The Blue Bells mining district contains the only current operation in the area, the Blackhawk properties, which have produced several thousand dollars in high-grade silver ores in recent years.

There are no records of production of metallic minerals from the West Tintic Range. However, large deposits of jasperoid may be an indication of possible mineralization at depth. Barring this possibility, the prospects of important mineral development in the West Tintic Range is considered unlikely.

## INTRODUCTION

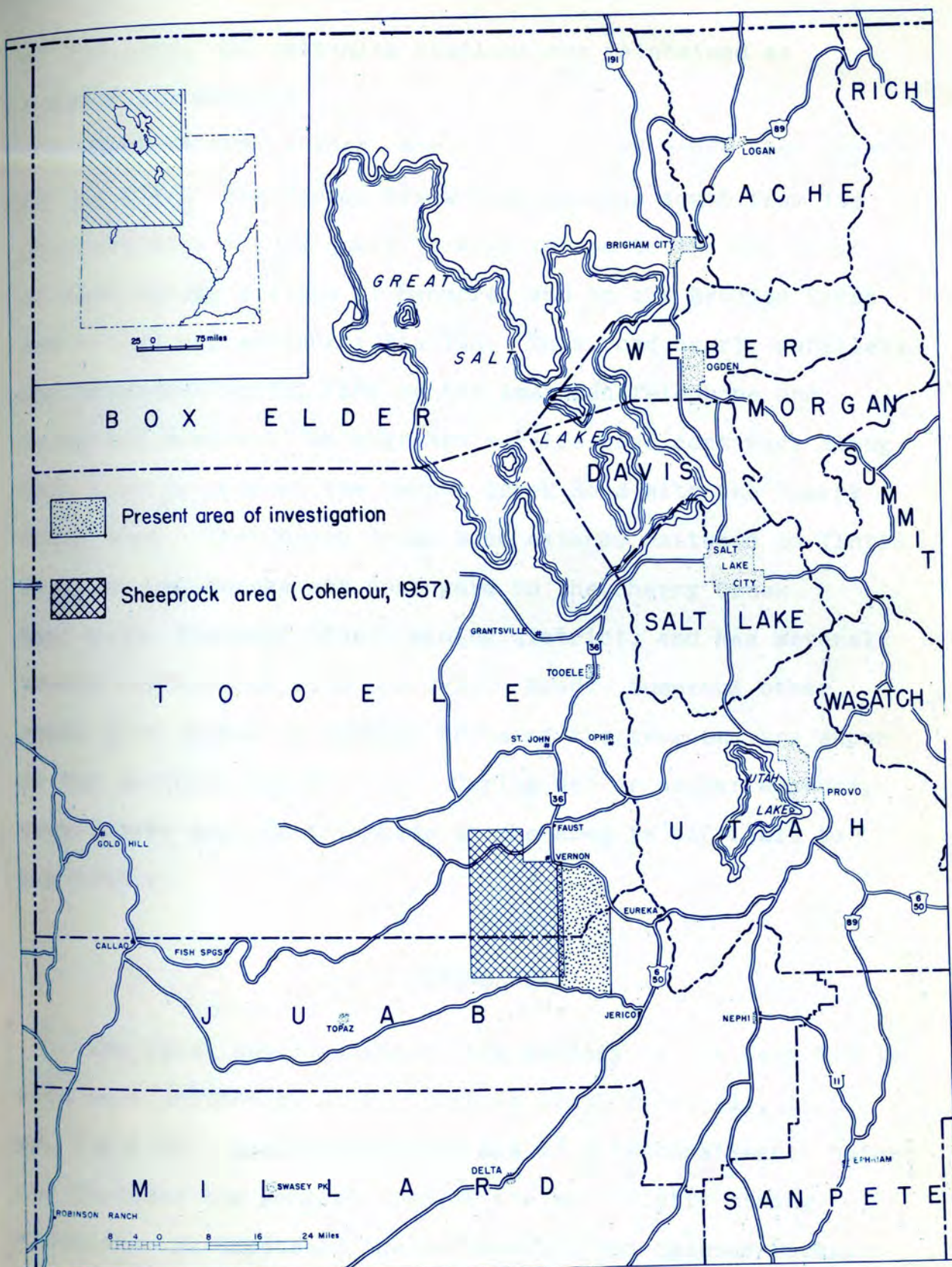
### LOCATION AND ACCESSIBILITY

The West Tintic Range and the portion of the eastern and southern flanks of the Sheeprock Range described in this report occupy parts of Tooele and Juab Counties, Utah. The mapped area comprises about 200 square miles, and is bounded on the east and west by longitudes  $112^{\circ} 15'$  and  $112^{\circ} 25' 15''$  W. respectively; on the north by Utah Highway 36; and on the south by the Jerico-No Name Road. Parts of Townships 8, 9, 10, 11, and 12 South and Ranges 4 and 5 West, Salt Lake Base and Meridian are included. The area includes all of the West Tintic Range, excepting the low hills north of Utah Highway 36 (Figs. 1 and 2).

The West Tintic area is about 80 miles south-southeast of Salt Lake City, and about 10 miles west of Eureka, Utah. The town of Vernon is situated approximately half a mile west of the northwest corner of the mapped area.

The main line of the Los Angeles and Salt Lake Railroad (leased to the Union Pacific) passes through the northeast part





(after Cohenour, 1957)

INDEX MAP OF WEST TINTIC-SHEEPROCK MOUNTAINS AREA

FIGURE 1

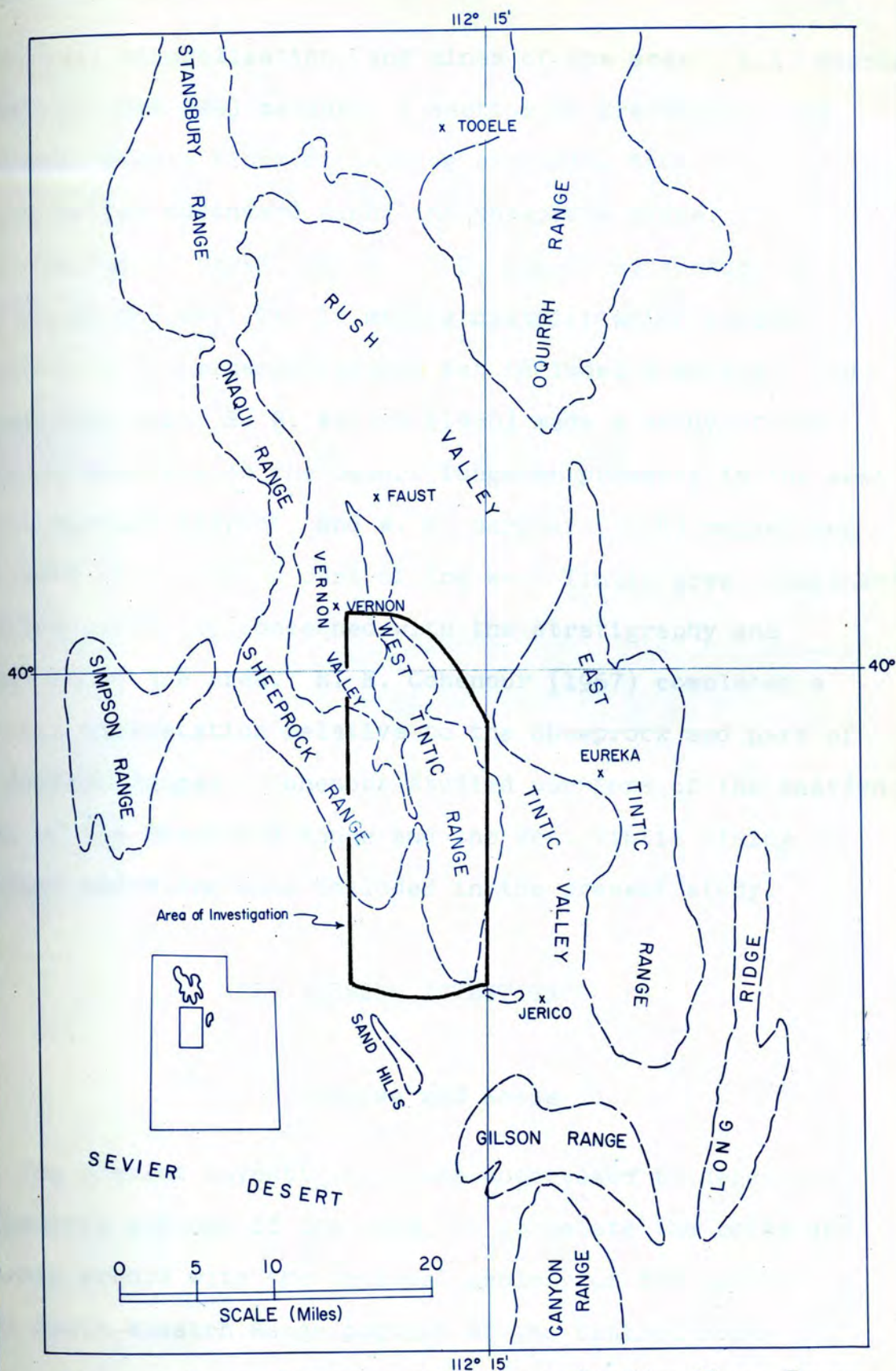
of the area, and switching stations are maintained at Lofgren and Boulter.

Several semi-graded, mostly unsurfaced roads give access to the area. The Vernon Creek Road extends south from its junction with Utah Highway 36 near Vernon to the U.S. Dept. of Agriculture station at Benmore, and to the Bennion Ranch and Little Valley Ranger Station. This road nearly parallels the transcontinental line of the American Telephone and Telegraph Company. An ungraded service road continues along this line to connect the Vernon Creek Road with the Cherry Creek Road. The Cherry Creek Road extends eastward to Tintic Junction and Eureka and southward to the Cherry Creek Reservoir, the West Tintic mining district, and has several branch connections with the Jerico Road. Numerous other roads give access to various parts of the area and are shown on the geologic map (Pl. I). During wet or winter weather, travel over most of the roads in the area is difficult to impossible.

#### PREVIOUS WORK

The first descriptions of the geology of the West Tintic area were written by G. F. Loughlin (Butler, et al., 1920, pp. 432-438). Loughlin's study was of a reconnaissance nature and included the general area of the West Tintic mining district. He discussed the sedimentary and igneous rocks,





BASIN AND RANGE GEOGRAPHY IN VICINITY OF THE WEST TINTIC RANGE

FIG. 2

structure, mineralization, and mines of the area. A.J. Eardley (1940, pp. 823-829) measured a section of Precambrian and Paleozoic strata along a traverse extending from the head of Little Valley northward along the Sheeprock Range.

B. F. Stringham (1942, pp. 267-270) published a study of a portion of the West Tintic mining district which treated essentially the mineralization, but included a geologic and topographic map. S. R. Wilson (1950) made a study of the tungsten deposits on the Desert Tungsten property in the West Tintic mining district, and W. C. Gardner (1954) mapped and described the southern part of the West Tintic area. Gardner's work was primarily concerned with the stratigraphy and structure of the area. R. E. Cohenour (1957) completed a doctoral dissertation relative to the Sheeprock and part of the Simpson Ranges. Cohenour studied portions of the eastern flank of the Sheeprock Range and the West Tintic mining district which are also included in the present study.

## THE PRESENT INVESTIGATION

### Purpose and Scope

The present investigation was undertaken to determine the general geology of the area, to correlate the rocks and tectonic events with the regional geology of the eastern Great Basin-Wasatch Range portion of the Central Rocky

Mountain Province and to contribute to the knowledge of the mineral potential of the West Tintic Range.

The West Tintic region is in a portion of the Rocky Mountain miogeosyncline that underwent subsidence in Paleozoic time, and is immediately west of the Eureka, Utah, shelf area. Thickening of Paleozoic strata is apparent from Eureka westward. The structure is complicated by Laramide features such as the Sheeprock thrust (Eardley, 1939, p. 1277), recumbent folds, and faults which may be superimposed on features related to the Early Cretaceous Cedar Hills orogeny. Ore deposits occur east and west of the West Tintic Range and a structural and stratigraphic study of the area would be a practical step in furthering the understanding of its mineral potential.

#### Field Work

Field studies were initiated in the summer of 1955, continued during the summer and early fall of 1956 and completed during the spring and summer of 1957. Mapping was done on aerial photos available from the Department of Agriculture. These were flown in the summer of 1952 at a scale of 1:20,000 by Aero Services Inc.

Tracing of geologic features was rendered difficult owing to the complex structure, alteration, and the ubiquitous alluvial cover. Extensive silicification and dolomitization have destroyed most of the fossil record.

## Laboratory Procedures

Fossils and rock specimens collected in the field were prepared and studied in the laboratory. Many fossils required only cleaning and washing prior to identification, but in many cases it was necessary to treat rock specimens with dilute hydrochloric acid and to identify insoluble residues by binocular microscope. Secondary dolomites were devoid of fossils, excepting those silicified during a previous period of alteration. Forty thin sections were prepared by the writer, and 21 more were supplied by the Bear Creek Mining Company. These were studied by means of the petrographic microscope.

## Geologic Map

Geologic data were plotted in the field on aerial photos, and transferred to a base map of which the southern three-quarters was prepared from a Fairchild controlled mosaic and the northern one-quarter compiled from a radial line assembly. Photographic enlargement of the assembly was necessary to match the scale of the mosaic.

The land survey grid was placed on the base map with reference to five located section corners, and from data on location surveys supplied by the American Telephone and Telegraph and Union Pacific Railroad Companies.

Cross-sections along designated lines on the geologic map (Pl. I), and drawn to the same scale, appear on Plate II.



## GEOGRAPHY

### Physiography

The area is near the eastern margin of the Great Basin (Atwood, 1940, p. 394), which is separated from the Wasatch Range and Colorado Plateau to the east by a narrow zone of complex normal faulting often designated as the "Wasatch Line" (Kay, 1951, p. 14). The West Tintic Range is typical of the north-trending fault-block ranges of the Great Basin. The Sheeprock Range lies west of the West Tintic Range (Fig. 2) from which it is separated by a southward extension of Rush Valley, herein called the Vernon Embayment, and the valleys of Vernon and Cherry Creeks (Pl. I). Little Valley and McIntyre Valley ascend westward from Vernon Creek and open into broad depressions in the eastern slope of the Sheeprock Range. Little Valley supports a perennial stream which is a tributary to Vernon Creek and supplies most of its water. Cherry Creek heads at Cherry Creek Springs about two miles south of the Dry Ranch (abandoned) and flows southward through a narrow valley which widens rapidly near the southern terminus of the Sheeprock and West Tintic Ranges. The Sand Hills and the north-eastern part of the Sevier Desert lie to the south (Fig. 2).

The eastern and southern slopes of the West Tintic Range are dissected by a number of dry valleys and washes that are for the most part unnamed. Southwest of Lofgren, Sabina Creek

drains the area east of Sabe Peak and empties north into Rush Valley. The stream in Sabina Creek is small and intermittent. Devils Creek and Death Creek extend eastward from near the center of the range and connect with Tanner Wash which drains southward through Tintic Valley.

The West Tintic Range is one to seven miles wide and is over 20 miles long. The longitudinal profile is irregular and low passes divide it into 3 parts. The Range culminates in Sabe Peak in the north-central part and Maple Peak in the south-central part. These peaks are respectively about 8016 and 8090 feet in elevation. The lowest elevation in the area is on Cherry Creek in the southwest corner of the mapped area and is estimated as 5300 feet. Accordingly the area possesses about 2700 feet of relief.

### Climate

The climate of the area is semi-arid. No weather stations are maintained in the area, but precipitation data from nearby stations is available. Partial records from the abandoned station of Faust to the north indicate annual precipitation as low as 6.43 inches (Gilluly, 1932, p. 3). Data from Eureka and Nephi show the average precipitation for the period 1931-52 to be 14.84 inches and 13.85 inches respectively. More recent data (1955) shows Eureka as receiving 15.22 inches, Nephi 13.35 inches and the new station at Dugway 7.38 inches.

Considering the location of the West Tintic area between the listed stations, a yearly average precipitation of about 10 inches can be inferred. Much of the precipitation is winter snowfall which is subject to strong evaporation by dry south winds in the spring, causing the loss or wastage of much of the moisture.

The precipitation supports a forest of juniper over much of the area, especially on the low-angle slopes where thick gravel retains considerable moisture. Scattered pinyon pine occur at higher elevations and on gravel slopes along the east flank of the range. Aspen, chokecherry, mountain oak, and willow trees are locally present in the washes and near creeks and springs. Sagebrush, rabbit brush, and various cacti are abundant over the lower unforested foothills. A recent dying of willow and aspen groves indicates a period of drouth which attained a maximum severity during the summer of 1956. During this season, the drying up of a number of formerly perennial springs caused great concern among the local inhabitants.

#### Land Utilization

The West Tintic area is utilized as a winter grazing range for sheep and as a summer range for cattle. A few nearby farms are irrigated on a small scale from the perennial streams. Gently sloping benches east of the range are cultivated for light yields of winter wheat. In 1955-57, dry-land farming was adversely affected by drouth.

Some mineral wealth has been won from the mines of the West Tintic district, though during 1955-57 no operations were active. In the Blue Bell district in the west-central part of the mapped area a mine in Little Valley provides a small return to its operators.

The area has been designated a game preserve and has a large deer and game-bird population. Vernon and Cherry Creeks contain large numbers of small trout. Rabbits, marmots, wild-cats, coyotes, and various birds of prey are much in evidence. Porcupines are so numerous that the scattered stands of pinyon pine, upon which they feed, are in danger of perishing in this area.

#### ACKNOWLEDGEMENTS

The staffs of the Geology and Mineralogy Departments of the University of Utah gave assistance and advice on field problems and in preparation of the dissertation. Dr. N. C. Williams suggested the problem and read the manuscript. Drs. W. L. Stokes and F. W. Christiansen gave helpful advice on field procedure and contributed to the discussion of stratigraphy and structure. Dean A. J. Eardley's constructive criticism of the geological map and advice on regional structural relations was invaluable. Dr. B. F. Stringham and Prof. Max Erickson aided in the field interpretation of igneous rocks and assisted the writer in petrographic identifications. Prof. Ray

Marsell provided encouragement and advice on problems regarding field interpretation. Dr. W. L. Stokes also identified many macrofossils and Dr. D. L. Jones identified the Green River microfossil fauna.

Thanks are also due to Walter Sadlick, who identified most of the Mississippian-Pennsylvanian fossil collections, to R. E. Cohenour, who guided the writer in an areal reconnaissance of the West Tintic area in the summer of 1955, to the personnel of the Dividend office of the Bear Creek Mining Company, who permitted the writer to reside in company quarters in the spring of 1957, and to Hal Morris of the U. S. Geological Survey who gave advice regarding identification and correlation of certain igneous and sedimentary rocks.

Mr. R. H. Pratt of the Mountain States Telephone and Telegraph Company and Mr. R. G. Duke of the Division Engineers Office, Union Pacific Railroad Company provided land plats and maps which were of great value in establishing the land grid on the geologic map. Mr. R. Brown of the Salt Lake County office of the Weather Bureau supplied information on precipitation.

Financial assistance was provided by two University of Utah Research Committee Fellowships and a two-month working salary from the Bear Creek Mining Company.

Last but not least, Mr. Uuno Sahinen of the Montana Bureau of Mines and Geology critically read the manuscript, and the writer's wife, Billie, typed the many pages of the early drafts of this work.



## STRATIGRAPHY

### GENERAL STATEMENT

Sedimentary and metasedimentary strata exposed in the West Tintic Range and in the portion of the Sheeprock Range within the mapped area have an estimated thickness of more than 22,500 feet. Precambrian clastic sedimentary strata are present over wide areas and exhibit complex structural relations. Strata of all Paleozoic systems are present, with the exception of the Permian. Parts of all systems have not been recognized, though it is probable that they are present in altered form or are obscured by Quaternary debris.

Mesozoic strata are absent, with the possible exception of an unnamed greenstone unit. Tertiary strata ranging from Paleocene(?) through Pliocene(?) occur along the eastern flank and in the central portion of the West Tintic Range. Thick deposits of Quaternary gravel, colluvium, alluvium, and aeolian deposits obscure much of the bedrock geology.

The strata described are tabulated in Plate III. Inferred regional correlations of the formations identified are shown by Plate IV.



Owing to the lack of continuous exposures it was necessary to execute many long traverses along the strike of traceable beds in order to obtain a continuous, but offset, section. The sections were measured by clinometer and pacing. Precambrian and Tertiary strata were not measured because of the confusing structural relationships and ubiquitous overburden. The partial Paleozoic section as measured by Gardner (1954) is included (Appendix A) for purposes of comparison.

The general topographic expression of the strata in the West Tintic area is a function of lithology, structural relationships, attitudes, and alteration. At places normally non-resistant formations or members are made resistant by silicification, in other places resistant beds may be weakened by shattering or alteration.

## PRECAMBRIAN ROCKS

### General Statement

The Precambrian strata exposed in the West Tintic area are clastic in nature, and range from fine-grained phyllitic shales to coarse conglomeratic tillite. The entire sequence has been affected by low-grade dynamic metamorphism and, in the vicinity of the West Tintic stock, dynamo-thermal metamorphism has imparted a schistose character to the rock.

The Precambrian in the adjacent Sheeprock Range was divided by Cohenour (1957, p. 11) as follows:

"Rock strata assigned to the Precambrian system aggregate about 11,000 feet in thickness and are divisible into two major sequences. The upper sequence is composed of argillites, quartzites, and conglomerates and is correlated with the Mutual formation. The lower sequence is divisible into three units based on lithologic features and stratigraphic position. The oldest unit is principally black slate and tan quartzite; the middle unit is a distinctive tillite; and the upper unit is mainly green and tan slates with subordinate quartzites."

The lower sequence of the three units was named the "Sheeprock Series" by Cohenour. The writer has examined this series as exposed in the Sheeprock Range, and has recognized its presence in the West Tintic area. The name "Sheeprock Series" is used to designate the lower sequence. The Mutual formation described by Crittenden (1952, p. 6) in the Big Cottonwood area of the Wasatch Range, and adopted by Cohenour for the upper sequence in the Sheeprock Range, is applied to the upper sequence in the West Tintic area.

The Sheeprock series is divisible, from the oldest to youngest units, as follows: (1) the older(?) schists, phyllites, and quartzites; (2) the lower phyllitic shales; (3) the lower quartzites; (4) the Dutch Peak tillite of Cohenour (1957); and (5) the upper phyllitic shales. The first unit is questionable and may, in fact, be the equivalent of one of the other units.

## Older(?) Schists, Phyllites, and Quartzites

Distribution.--Three areas of exposure of the older(?) schists, phyllites, and quartzites are shown on the geologic map. Two of these are located on the high ridge west of Horse Valley near the west edge of the mapped area in sec. 35, T. 10 S., R. 5 W.. A larger, but mostly covered, exposure occurs in the West Tintic mining district in the vicinity of Great Eastern Hollow and in sec. 19, T. 11 S., R. 5 W..

Lithology.--The most abundant rock type is brown to purplish-brown quartzite. It is fractured, sheared, and, in the southern exposures, is associated with conglomeratic phyllite and some micaceous schist. The lithology does not resemble other Precambrian units.

Age and correlation.--These rocks are thought to be the oldest exposed in the area. The possibility that they are merely a more metamorphosed equivalent of other units in the Sheeprock series must not be overlooked. Actually, this unit was proposed because of inability to establish lithologic correlation with other units in the series.

## Lower Phyllitic Shales

Distribution and thickness.--A few hundred feet of phyllite are exposed in stream gullies below the high ridge west of Horse Valley in sec. 19, T. 11 S., R. 5 W.. Cohenour (1957,

p. 13) called these rocks, the "black-banded phyllite", but they are designated as the lower phyllitic shales in the present paper because of their stratigraphic position below another phyllite unit.

The area of exposure is complexly faulted and folded and an accurate measurement was not obtained. Cohenour (1957) measured 2,609 feet of this unit at a more favorable site in the Sheeprock Range.

Lithology.--The rock is a phyllitic shale characterized by black bands a fraction of an inch in thickness alternating with thicker bands of silvery-gray, gray and tan-gray. The alternate color bands present an appearance quite similar to varved clay. A dark purplish-weathering, fine-grained tillite crops out in small patches in the same area, and may be a part of the lower phyllitic shales or faulted remnants of the younger Dutch Peak tillite.

The phyllite is exposed in topographic lows and has a dark coloration when viewed from a distance. Close folding and shearing was observed in most outcrops.

Age and correlation.--A sequence of exposures was traced stratigraphically upward from the phyllite unit through the lower quartzite unit and into the Dutch Peak tillite. A portion of the overlying quartzite contains many fragments of banded phyllite and some fractured pebbles of the same phyllite were found in the Dutch Peak tillite. These features indicate that the phyllite is the older unit.

Similar banded phyllites associated with a tillite sequence were reported by John Hazzard (1957, personal communication) in connection with studies in the Deep Creek Range of Nevada (Misch, et al., 1957, p. 1837). Blackwelder (1932, pp. 294, 297) has discussed laminated phyllites and tillites in the Wasatch area, Ludlum (1942, p. 92) cited the occurrence of "varved slates" east of Pocatello, Idaho, and more recently Larsen (1957, pp. 66-67) described varved zones in the Mineral Fork tillite of Antelope Island.

#### Lower Quartzites

Distribution and thickness.--Exposures of the lower quartzite unit crop out in the high hills west of Little Valley and Horse Valley at the western edge of the mapped area where the strata are intruded(?) by at least one diabasic sill or an altered Precambrian lava flow. The unit is also exposed in Little Valley at the Blackhawk Mine. Other exposures, apparently overturned, are in the ridge between McIntyre and Horse Valleys, in the fault complex west of McIntyre Mountain, and in the high ridge north of Chicken Rock in the West Tintic mining district.

No complete sequence of this unit occurs in the area of investigation. Cohenour (1957, p. 13) states that the quartzite unit conformably overlies the black banded phyllite, and ranges between 1,350 and 1,470 feet in thickness.



Lithology.--Quartzites compose nearly the entire unit. These vary somewhat in texture and color, and contain a minor amount of slate and a considerable thickness of an interbedded flow(?) rock. The first exposure above the phyllite is a greenish to tan quartzite which weathers with a "Swiss cheese" appearance owing to the presence of flakes of the soft underlying phyllite. Above the "Swiss cheese" horizon, the quartzite is a fairly uniformly textured, medium-grained, dark-tan rock containing scattered magnetite grains. This portion is estimated at more than 1000 feet in thickness, and is overlain by a brown-weathering, dark-green diabasic rock. In a few places the diabasic rock is bordered by green slate lenses in the quartzite. Cohenour (1957, p. 14) cites its thickness as ranging from a feather edge to 100 feet or more in thickness. This diabasic unit is useful in determining the proximity of the top of the lower quartzite unit, as it seems to be confined to essentially the same horizon in all the exposures noted. The exposure of the lower quartzite near Chicken Rock was tentatively identified by the occurrence of abundant diabasic float near the quartzite-tillite contact. Next above the diabase is a unit of about 40 feet of dark gun-metal gray, fine-grained, flaggy quartzite strata. Overlying the gray quartzite is an equivalent thickness of tan-gray to bluish medium-grained quartzite which seems conformably to underlie the Dutch Peak tillite.



Age and correlation.--The lower quartzite unit is older than the Dutch Peak tillite, and is correlated with the pre-tillite quartzite of the Sheeprock Range.

### The Dutch Peak Tillite

General statement.--Unsorted conglomeratic phyllites in the West Tintic mining district were observed by Loughlin (Butler, et al., 1920, pp. 424-425), who suggested a glacial origin. Eardley (1940, pp. 825-826, 832) later measured 1100 feet of this conglomerate and identified it as a tillite. Cohenour (1957, p. 15) named the sequence the Dutch Peak tillite from the excellent exposures found on the flanks of Dutch Peak in the Sheeprock Range.

Distribution and thickness.--The Dutch Peak tillite is exposed over large areas of the eastern and southern flanks of the Sheeprock Range. In these areas it forms a part of the Precambrian allochthon of which isolated remnants occur to the east in the West Tintic Range. Broad exposures of the tillite occur in and south of Little Valley and extend eastward from Vernon Creek to the west flank of the West Tintic Range. Another large exposure crops out in the higher hills near the southern terminus of the West Tintic Range. A number of klippen, partly concealed by Cenozoic deposits and colluvium are located about  $1\frac{1}{2}$  miles northwest of McIntyre Ranch in secs. 29 and 31, T. 10 S., R. 4 W.. Exposures of Precambrian

rocks in the West Tintic mining district are predominantly tillite that has been affected by different degrees of dynamic and thermodynamic metamorphism.

The tillite apparently varies greatly in thickness, but no actual measurements were made in the area of investigation. Cohenour (1957, p. 17) measured 4,044 feet of tillite on the north slope of Dutch Peak at the type locality in the Sheep-rock Range. In Pole Canyon, just west of Horse Valley and beyond the boundary of the present report, Cohenour measured 2,555 feet of tillite.

Lithology.--The Dutch Peak tillite is normally a dark olive-green conglomeratic rock displaying a well-developed cleavage that usually transects the bedding (Pl. V, A). The tillite generally weathers dark olive-green, but in types having a fine-grained matrix it may weather to a dark purple-brown. Boulders, cobbles, and pebbles of wide range of size and composition are dispersed at random in an equally unsorted but finer-grained matrix.

The conglomeratic fraction consists of fragments of gneiss, schist, granite, limestone, vein quartz, quartzite, older tillite, banded phyllite, and rarely diabase. Most of the larger fragments are rounded and nearly spherical, but some are subrounded and aspherical. No glacial striae or facets were seen. Of particular interest is the occurrence of a bright green quartzite found in random association with the



A.--Tillite exposure along the Vernon Creek Road. Note the conglomeratic material and slaty cleavage. View is to the north.



B.--Resistant beds of fine-grained, dark-weathering tillite west of McIntyre Valley. Note the less resistant tillite in the stream bed at the left. View is to the south.

fraction. N. C. Williams (1956, personal communication) suggested that the green color may be due to the presence of chrome-bearing mica, fuchsite, in the cementing material. Larsen (1957, pp. 80-81) X-rayed specimens of green quartzite-schist from the Antelope Island and Raft River Range areas, but found the flakes too small to be analysed by this method.

In the more southerly exposures, the tillite has a schistose appearance, and locally the constituent fragments are elongated parallel to the direction of foliation. The schistose tillite locally has a silvery sheen, and may weather to a dark purple-brown.

Stratification is generally absent, excepting near the base and top of the tillite which contains at least three quartzite members or lenses up to 100 feet thick. The quartzite members range from a light blue-gray to tan, usually have brown limonite stains on weathered surfaces, and are generally highly fractured and displaced by small faults. The attitude of the tillite, however, may be determined from some of the quartzite outcrops.

A dark purple-brown-weathering tillite having a fine-grained matrix containing scattered pseudomorphs of cubic limonite is exposed north of the road that connects McIntyre and Horse Valleys, and a similar tillite occurs in questionable association with the banded phyllite west of Horse Valley. The latter exposures were not mapped owing to the small area of exposure, but are possibly older than the Dutch Peak

tillite. However, there are too few exposures to establish the sequence, and all of the tillites exposed were mapped as the Dutch Peak tillite. The possible significance of the limonitic tillite is discussed in the section treating the origin of the Precambrian strata.

Petrography.--Petrographic examination of a typical tillite specimen shows a matrix of fragmental quartz, plagioclase, and some microcline scattered in a still finer mass of the same minerals with much chlorite and sericite. The mica flakes are oriented parallel to the megascopic fracture cleavage. Some magnetite or hematite is also present. The texture is cataclastic. Considering the difference in metamorphism, the petrographic resemblance to the tillite of Antelope Island (Larsen, 1957, p. 70) is remarkable.

Examination of the fine-grained limonitic variety of tillite, showed that the matrix is predominantly quartz with a few fragments in the size range of a sandstone, and downward from this to below the resolving power of the microscope. Most of the quartz fragments are oriented roughly parallel to the lineation of the fine matrix, which has much micaceous material oriented parallel to the megascopic fracture cleavage. No optically preferred orientation of quartz fragments was observed. Limonite is scattered through the matrix, and often occurs as large blebs which may cut across the lineation. A dark opaque material present is probably  $MnO_2$ , which may account for the purple-brown weathered color.



Age and correlation.--It is probable that the Dutch Peak tillite was deposited during the same interval as were other Precambrian tillites of the Wasatch Mountains and Basin and Range region. F. F. Hintze (1913, pp. 99-100) was the first to report the presence of tillite in the Wasatch Mountains. The name "Mineral Fork tillite" was applied by Crittenden (1952, p. 4) to tillite exposures in the Big Cottonwood area of the Wasatch Range. Cohenour (1957, p. 15) considers the Dutch Peak tillite to be in part the age equivalent of the Mineral Fork, and cites a number of reasons for not using the type name for the lithologically similar tillites of the Sheeprock area. Chief among these reasons is that the upper and lower contacts of the two tillites are distinctly different. The Mineral Fork tillite at its type locality lies unconformably in scooped out basins in the much older Big Cottonwood series (Crittenden, 1952, p. 5), and is unconformably overlain by strata of the Mutual formation. The apparently conformable relationship of the tillite of the Sheeprock-West Tintic area justifies a separate name. Actually, the Mineral Fork tillite of the Big Cottonwood area may represent only a small portion of the time span involved in the deposition of the much thicker Dutch Peak tillite.

The Mineral Fork tillite of the Big Cottonwood area and of Antelope Island (Larsen, 1957, pp. 64-70), the tillite reported by Hazzard (Misch, et al., 1957, p. 1837) in the Deep Creek Range of Nevada, and the tillite of the Bannock Range

east of Pocatello, Idaho (Ludlum, 1942, p. 90), are essentially correlative in time with the Dutch Peak tillite.

### The Upper Phyllitic Shales

Distribution and thickness.--The largest exposure of the upper phyllitic shales is just north of Little Valley. The unit is largely covered, but extends from the west edge of the mapped area across the north divide of Little Valley where it is partially overlain by a Mutual(?) quartzite klippe. The unit is also exposed in this area on the east side of Vernon Creek. A smaller exposure is west of Horse Valley, near the west border of the geologic map, in the southwest portion of sec. 33, T. 10 S., R. 5 W..

According to Cohenour (1957, p. 14), the estimated thickness of the upper phyllitic shale is between 2,000 and 3,000 feet in the Sheeprock area. The entire thickness is not exposed in the West Tintic area.

Lithology.--The upper phyllitic shale unit consists of olive-green, olive-drab, and tan phyllitic shales in the West Tintic area. The slaty cleavage is parallel to the bedding. Reddish-brown ferruginous liesegang type (Lindgren and Loughlin, 1919, p. 156) banding commonly parallels joint systems and may be confused with primary features in more massive parts of the unit. The unit is incompetent and has been severely folded and faulted.

It is relatively nonresistant to weathering and tends to form topographic lows, except where capped by resistant rocks.

Age and correlation.--The upper phyllitic shales are the highest unit of the Precambrian Sheeprock series and appear to overlie conformably the Dutch Peak tillite. The upper contact of the unit with the Mutual(?) formation is not exposed in the West Tintic area, but pebble conglomerate containing abundant clay galls near the base of the Mutual(?) suggest the probability of a disconformity at the top of the Sheeprock series. Possible regional correlations of the Sheeprock series are discussed in a subsequent section of this paper/

#### The Mutual(?) Formation

Distribution and thickness.--The Mutual(?) formation is poorly exposed in the West Tintic area. It overlies the upper phyllitic shales of the Sheeprock series at the south end of the Vernon embayment. The exposures in this area extend east of Vernon Creek, and the northernmost outcrops occur in secs. 34 and 35, T. 9 S., R. 5 W.. The Mutual(?) strata of these northern exposures are part of an eastward-thrust allochthon. Slope wash and residual cover are so extensive that it is practically impossible to measure a section with any degree of accuracy.

A better exposure is present south of Horse Valley and north of the prominent east-west high-angle fault that parallels Indian Hollow. The strata are inverted, and were involved in thrusting and recumbent folding.

A faulted thrust remnant of Mutual(?) quartzite caps Maple Peak, and other klippen composed of Mutual(?) occur in the vicinity and to the west and southeast of Maple Peak.

The Mutual(?) strata were not measured in the West Tintic area, but Cohenour (1957, p. 22) reports a thickness of 924 feet in Talawag Peak in the Sheeprock Range. A minimum thickness of 3,000 feet is estimated for the Mutual(?) strata partially exposed east of Vernon Creek and south of the Vernon-Lofgren Road. This estimate is based on a foot-traverse across a 90 percent covered section in sec. 35, T. 9 S., R. 4 W.. The attitude changes do not appear to be abrupt, and, if the possibility of unobserved faults repeating the strata is ruled out, the Mutual(?) section is over three times as thick in the West Tintic area as it is in the adjoining Sheeprock Range.

The apparent thinning of the Mutual(?) strata in the Sheeprock area relative to the West Tintic area, is likely due to local conditions of non-deposition in the Sheeprock area. The presence of clay galls in pebble conglomerates near the base of the Mutual(?) is indicative of subaerial conditions and supports the possibility of a period of local non-deposition.

Lithology.--Exposures of Mutual(?) strata in the West Tintic area are predominantly quartzite. Sufficient outcrops are present in the northern area to permit a rough description from near the base to the highest outcrops observed. Near the base is an unknown thickness of gray quartz-pebble conglomerate containing abundant red, yellow, and gray clay galls. Next above this is a gray, rather coarse-grained quartzite containing enough feldspar to impart a salt and pepper appearance to weathered surfaces. A thick sequence of finer grained maroon quartzites and micaceous argillites apparently overlies the gray quartzite. This sequence is, in turn, overlain by brown- and tan-weathering light-gray quartzite alternating with at least two green and tan shale beds over 100 feet in thickness. Above the topmost light-gray quartzites of this unit are maroon and purple banded quartzites (Pl. VI, A) which become conglomeratic upwards, and, near the highest exposures, contain abundant red jasper pebbles. This uppermost observed sequence is the equivalent of the Talawag member described by Cohenour to differentiate the upper portion of the Mutual(?) formation from the overlying Tintic quartzite.

The large klippe(?) north of Little Valley is composed mostly of the salt-and-pepper-weathering quartzite. This klippe is presumably a remnant of imbricate thrusting, but the amount of displacement is quite small. Cohenour (1957, Pl. I) mapped this feature and the isolated hill about a mile north as questionable Tintic quartzite. However, this klippe and





A.--Mutual(?) quartzite, showing color banding in talus block locked in sec. 35, T. 9 S., R. 4 W., near the crest of the ridge east of Vernon Creek.



B.--Clay galls in Mutual(?) conglomerate. The exposure is near the access road on the ridge southeast of Horse Valley.

isolated hill are interpreted herein as consisting of Mutual(?) strata. The klippe contains a lithology not seen in the Tintic quartzite, and the isolated hill consists of quartzite strata of similar lithology and attitude to the Mutual(?) strata exposed across Vernon Creek a mile to the east.

Exposures south of Horse Valley are dominantly quartzite. A maroon and purple, and locally green conglomeratic quartzite, contains clay galls as much as ten inches in mean diameter Pl. VI, B). This unit is overlain in an overturned sequence by 100 feet more or less of green shales, and these, in turn, are overlain by approximately 100 feet of quartzite similar to that below the shales. A white, tan-weathering quartzite is the topmost unit of the fairly flat-lying beds in the area of exposure. However, if the beds are overturned, as the evidence of cross-bedding on the north wall of Indian Hollow indicates, the topmost unit is actually the oldest stratigraphically.

The lithology of the many klippen in the Maple Peak and south-central area differs considerably. However, the widespread presence of the maroon and purple conglomeratic quartzite served as the basis of classifying most of the klippen as Mutual(?) formation.

Age and correlation.--The upper and lower contacts of the Mutual(?) are concealed in the West Tintic area. However, these contacts were observed in the Sheeprock Range by Cohenour (1957, p. 24), who states:

"Questionable unconformities occur above and below the Mutual(?) facies in the Sheeprock area."

This unit is correlated with the Mutual(?) of the Sheeprock Range and with the Mutual of the Big Cottonwood area (Crittenden, 1952, p. 6) because of similar stratigraphic position and lithology. In its type area the Mutual formation unconformably overlies the Mineral Fork tillite, and is, in turn, unconformably overlain by the Tintic quartzite.

The Cottonwood slates, described by Muessig (1951, pp. 12-14) in the Long Ridge, Utah, area, consist of 2,836 feet or more of Precambrian slates, argillites, and phyllites, with a gritty pebble conglomerate at the base of the Tintic quartzite. The similarity of stratigraphic position and lithology is suggestive of a possible correlation with the Mutual(?) strata of the West Tintic-Sheeprock area.

## ORIGIN AND REGIONAL CORRELATION OF THE PRECAMBRIAN ROCKS

### Origin of the Precambrian Strata

The sequence of banded phyllites, quartzite, tillite interbedded with units of pure quartzite, and phyllitic shales which is present in the Sheeprock series, represents unusual conditions of deposition. Relatively rapid changes of sediment-producing environments is necessary to account for these strata. The tillites and banded (varved ?) phyllites are probably the products of glacial and glacio-lacustrine or fiord-type sedimentary environments. Semibedded facies of the

tillite are probably glaciofluvial in origin. However, the rather abrupt vertical lithologic and thickness change of the strata are difficult to explain.

Similar tillite, banded phyllite, and quartzite associations have been reported in the Wasatch Range (Blackwelder, 1932, pp. 294, 297, 302), on Fremont Island (Eardley, 1940, p. 832), on Antelope Island (Larsen, 1957, p. 66), east of Pocatello, Idaho (Ludlum, 1942, pp. 90-91), and in the Deep Creek Range of Nevada (John Hazzard, 1957, personal communication). Thus, it appears that the unusual lithologies of late Precambrian time are regional in extent.

The origin of the Precambrian sediments was considered by Eardley (1940, pp. 829-834) who stated:

"The physiographic setting of the time of deposition is of primary concern in formulating a theory of origin of the sediments."

In accordance with this idea, Eardley proposed the existence of highlands and troughs in the Northern Utah region of late Precambrian time. The Sheeprock-West Tintic area was considered to be the site of a subsiding trough bounded on the north by the Northern Utah Highland, and on the east by the Willard Ridge. To account for the origin of the banded phyllite-quartzite association, and the unbanded phyllite-quartzite association, Eardley (1940, p. 833) proposed a multiple environment theory. This theory ties the glacial and fluvial erosion of the highlands to glacial, glaciofluvial, glaciolacustrine, fluvial, beach, and offshore marine environments of deposition.

The existence of fiord-cut coastlines bordering the late Beltian "Sheeprock sea" is proposed to explain the lithologic associations of the Sheeprock series. Brackish, non-circulating waters of the partially landlocked fiords would be a suitable environment for the deposition of varved clays. Stagnation and the development of euxinic conditions could produce  $\text{FeS}_2$  and explain the cubic limonite pseudomorphs contained in the fine-grained tillite. The changing regimen of glacial conditions could cause an alternating deposition of till and varved clays. Circulation changes attending eustatic changes of sea level and the erosion of the fiord barrier may have prevented the formation of varves and a rising sea level could be expected to cause deposition of beach sands over the glacial material in the fiord depths. Thus, eustatic fluctuations might account for the quartzite members of the Dutch Peak tillite. A major transgressive-regressive phase would likely remove most of the previously deposited material, except that below the erosive effect of waves, and may account for the relative paucity of ancient glacial deposits in the region.

Not all of the strata of the Sheeprock series were deposited in fiords, but it is possible that fiord conditions may account for the characteristics of some of these strata.

In a fiord environment, it seems reasonable that a depositional series would begin with a tillite. It is possible, then, that tillites older than the Dutch Peak tillite are present in the area. It is not certain that such older tillites



are exposed in the Sheeprock-West Tintic area, but more specific future studies may decide this issue.

### Regional Correlation of Precambrian Strata

The Precambrian strata of the West Tintic area are considered late Precambrian in age and are tentatively correlated in time of formation with the extensive upper Beltian Missoula group of clastics (Clapp and Deiss, 1931, pp. 677-683) in western Montana. This tentative correlation is based on; (1) the clastic nature of the rocks in both localities, (2) the fact that both clastic sequences are younger than carbonate strata which contain a Stromatolite fauna (Rezak, 1957a, p. 136), (3) the similarity of the Mutual(?) and Missoula-type lithologies, and (4) the apparent stratigraphic position at or near the top of the Precambrian system. A further consideration of (2), is that concentric algal or Stromatolite structures were observed in limestone cobbles in the Dutch Peak tillite--indicating the existence of a pre-tillite limestone in the source area. In connection with (3), the writer is well acquainted with the Beltian rocks in Montana and is impressed by the lithologic similarity of the Missoula group to the Mutual(?) strata. Clapp (1932, p. 22) estimated the Missoula group to have a maximum thickness of 18,000 feet in the Missoula-Helena area, and believed the total thickness of the Belt series to be as much as 48,000 feet.

The late Precambrian(?) Bridger arkose and LaHood conglomerate of Gallatin and Jefferson Counties, Montana somewhat resemble tillite in lithology and occurrence. W. J. McMannis (1959, written communication) states that petrographic features of these rocks are virtually identical to those of the Dutch Peak tillite as described in this paper. However, the origin of the Montana units has not yet been decided.

The quartzites exposed in the Big Cottonwood area of the Wasatch Range were considered by F. F. Hintze (1913, p. 97) to be possibly equivalent to the Belt series of Montana and the Grand Canyon series of Arizona. Blackwelder (1949, p. 30) stated the problem of regional correlation:

"There is some difference of opinion regarding the correlation of these younger pre-Cambrian rocks with those of other parts of western United States. Most students of the subject are impressed with their general similarity to the late pre-Cambrian Grand Canyon system of Arizona and to the Belt system of western Montana. In all these localities the formations underlie Middle or Lower Cambrian rocks with an unconformity which is often obscure. They resemble each other in consisting largely of sandy and shaly beds of continental origin and in having been no more severely metamorphosed than the associated Paleozoic strata."

The late Precambrian strata of the Sheeprock-West Tintic area are considered the approximate age equivalent of the Big Cottonwood(?) formation of the East Tintic Range (Morris, 1957, p. 3), the Cottonwood(?) slates of the Long Ridge area (Muessig, 1951, p. 12), the Mineral Fork tillite and Mutual formation of the Big Cottonwood area (Crittenden, et al., 1952, pp. 4-6), the Mutual quartzite and Red Pine shale of the

uinta area (N. C. Williams, 1953, pp. 2727-2738), the Mineral Fork tillite and Mutual(?) formation of Antelope Island (Larsen, 1957, pp. 68-76), and the younger Precambrian sequence of the Promontory Range (R. H. Olson, 1957, pp. 43-44).

## CAMBRIAN SYSTEM

### General Statement

Cambrian strata are present in the West Tintic area, but exposures of all units except the Tintic quartzite are small. The strata have been involved in thrusting and other structural complications. A thickness of 2,327 feet of Cambrian strata was measured in the West Tintic area as compared to the more than 8,000 feet measured by Cohenour (1957, Pl. XVII) in the Sheeprock Range. Structural complications and alteration may have masked the true identity of the strata, or crustal shortening may be involved in the overall area of the Sheeprock uplift. In the latter case, the Cambrian strata of the Sheeprock Range may represent a sequence deposited a considerable distance west of its present location.

The West Tintic Cambrian units resemble those of the East Tintic Range, about 10 miles to the east, though one unit is missing and three others cannot be differentiated.

## The Tintic Quartzite

Distribution and thickness.--The largest exposure of the Tintic quartzite in the West Tintic area is in the vicinity of Sabe Peak, where more than two square miles of allochthonous Tintic were mapped. The area is largely covered with quartzite float which obscures all but the measured 887 feet of strata. Structural complications are present, and the bedding is obscure at most exposures.

A low hill composed of Tintic quartzite is present as a small fenster in the upper phyllitic shale unit of the Sheeprock series about a mile west of Sabe Peak. A klippe of Tintic quartzite forms the crest of a hill in sec. 13, T. 10 S., R. 5 W. about a mile southwest of Sabe Peak. Other Tintic exposures are shown on Plate I.

An incomplete section of 887 feet of Tintic quartzite is exposed in the West Tintic area. Cohenour (1957, p. 29) reports 2,572 feet in the northern Sheeprock area, and Morris (1957, p. 4) gives the thickness of the Tintic quartzite as 2,300 to 3,200 feet in the East Tintic Range.

Lithology.--The Tintic quartzite exposed in the West Tintic area is characteristically a medium-grained quartzite of white, pinkish, or tan color. In outcrop the quartzite may be white, tan, and light brown with much limonite staining in places. The quartzite consists of medium-sized grains with a fair to high degree of rounding with coarse grains of rose

quartz locally occurring in great abundance. Bedding is indistinct, but more well-defined beds occur near the top, and include interbedded olive-green argillaceous quartzites. The bedding is often more easily recognized from a distance.

The Tintic quartzite is a resistant rock and forms hills and ridges. Its most characteristic features are the rose quartz grains and the pinkish color of some of the strata. This pink color was not observed in any other quartzite exposed in the area.

Age and correlation.--The Tintic quartzite was identified in the West Tintic area by its lithologic similarity to the Tintic quartzite in the type area of the East Tintic Range, where it was named by Smith, Tower, and Emmons (1900, p. 1). The Tintic quartzite is early Cambrian in age according to Morris (1957, p. 4), who places the top of the Tintic at the top of the uppermost buff colored quartzite below the olive-green shale of the Ophir formation. The base of the Tintic is drawn by Morris (1956, personal communication) above a jasper-pebble conglomerate zone in the underlying Precambrian strata.

The Tintic quartzite extends from the Sheeprock Range (Cohenour, 1957, pp. 29-34) through the West Tintic, East Tintic, and Long Ridge (Muessig, 1951, p. 193) areas to the Wasatch and Uinta Ranges (N. C. Williams, 1953, pp. 2738-2739). Everywhere in this general region it unconformably overlies Precambrian or Mutual strata, except in the Promontory Range



where R. H. Olson (1957, p. 44) recognized the equivalent Prospect Mountain quartzite and reports that the contact with the Precambrian is gradational. In addition to the Tintic quartzite, the Prospect Mountain quartzite of the Gold Hill, Utah area (Nolan, 1935, p. 6), the Brigham quartzite of western Montana are considered by the writer to belong to the same magna-facies (Krumbein and Sloss, 1951, pp. 265-266) deposited by the transgressing Cambrian sea.

Measured section.--The following section was measured up the southwest flank of Sabe Peak in a general west to east direction and continued southeast along the high ridge south of Sabe. Units are numbered upwards from older to younger strata. The base and most of the formation were not exposed, and a fault zone separates the top of the Tintic from the undifferentiated limestone-shale sequence.

Tintic quartzite:

	Feet
19. Quartzite breccia, fault zone, red-brown stain.....	30
18. Quartzite, gray, weathering gray and brown, medium-grained.....	7
17. Quartzite, fractured zone, dark rust stain.....	5
16. Quartzite, pinkish-white, weathering light tan and white, fine- to medium-grained.....	57
15. Quartzite, olive-green, weathering olive-brown, banded parallel to bedding, fine- to medium-grained.....	3
14. Quartzite, same as 16.....	14

13. Quartzite, pinkish-gray to olive gray, weathering to an overall olive-brown, darker bands paralalled to bedding; some small scale cross-bedding; slaty cleavage in finer-grained type.....	30
12. Quartzite, fracture zone, rusty breccia.....	4
11. Quartzite, white, weathers tan to brown, some darker bedding features, medium-grained.....	5
10. Quartzite, light-olive-green, weathers green to brown, darker bands parallel to bedding, medium-grained.....	5
9. Quartzite, pink-white, weathers light-brown to tan-gray, larger rose quartz grains in medium-grained matrix, has faint bedding.....	19
8. Quartzite, tan-white, weathering light-brown to light-gray.....	127
7. Quartzite, fracture zone, reddish stain.....	17
6. Quartzite, olive-crab, weathering to a rusty greenish-brown, fine- to medium-grained, some darker banding parallel to bedding.....	51
5. Quartzite, light-pinkish-gray, weathers gray to light brown, unsorted, pink grains to 5 mm in medium-grained white quartzite.....	256
4. Quartzite, uniform pinkish color, weathering tan, well-sorted, medium-grained, faint bedding.....	147
3. Quartzite, same as 4, fracture zone.....	45
2. Quartzite, same as 4, but is pinkish-white and has well defined bedding and occasional coarse grains of rose colored quartz, also a few thin beds of coarse, semi-rounded vein quartz grains..	48
1. Quartzite, same as 2, but without coarse grains.....	36
Total exposed Tintic quartzite.....	887

## Undifferentiated Limestone-Shale Sequence

Distribution and thickness.--The largest exposures of the undifferentiated limestone-shale sequence occurs in a strongly folded and faulted area south of the Tintic quartzite exposures in Sabe Peak.

Small exposures of the undifferentiated sequence crop out in the saddle between two quartzite hills southwest of McIntyre Valley in sec. 11, T. 11 S., R. 5 W., and in a low hill north of No Name Road in sec. 22, T. 12 S., R. 4 W..

The total measured thickness of the exposed sequence is 691 feet, but is subject to error because of possible unrecognized strike faults. The measured section has a fault of unknown displacement at the base and includes a very small portion of the younger Opex-Ajax formation. The latter strata are apparently in a small thrust remnant whose contacts are not distinguishable owing to similarity of lithology and attitude to the underlying undifferentiated sequence.

Lithology.--The limestone-shale sequence is normally a thin-bedded, locally pisolitic(?) argillaceous limestone. Green to tan fissile shales occur near the base in several horizons, where they are mostly obscured by more resistant limestone float. The lower limestones of the exposures are especially characterized by the presence of pisolites (or the algae, Girvanella), which are as much as one inch in diameter and normally weather reddish brown. Above the pisolitic limestones,

the strata are thin-bedded limestones with abundant yellow blebs and partings of argillaceous material. Dolomite occurs in bands and irregular masses along almost all faults, and was observed to cross the bedding planes. Considerable shearing along bedding is probably responsible for the rarity of fossils. Abrupt changes of attitude and some tight folding are present in several localities.

Age and correlation.--The limestone-shale sequence closely resembles the Ophir formation, Teutonic limestone, and Herkimer limestone of Middle Cambrian age in the East Tintic Range.

A Glossopleura fauna found in the lowest exposed green shale, is characteristic of the upper shales of the Ophir formation, and, according to R. Bright (1957, personal communication), one specimen identified as Glossopleura cf. G. producta represents approximately the horizon of the Middle Cambrian Millard limestone of the House Range (Wheeler and Steel, 1951, p. 35). Cohenour (1957, p. 50-51) collected one specimen of this species from the Millard formation of the Ophir group of the Sheeprock Range, and describes pisolitic or algal ball zones in the upper and lower units of the Millard. Morris (1957, p. 6) reports globular algal structures from the basal Teuronic limestones of the East Tintic Range.

The pisolites, algal balls or any other layered pellets occurring in early Paleozoic strata have been referred to as Girvanella. According to Rezak (1957a, p. 1411), Girvanella

are not a guide to the Cambrian, and the genus is known to range from Cambrian through Lower Cretaceous. Rezak states also that microscopic tubules, not the concentric nature of the pellets are the identifying characteristic of the genus Girvanella. Therefore, the pisolite zones are useful only as a basis for lithologic correlation in the West Tintic and adjacent areas.

The base of the exposed section of the limestone-shale sequence is here correlated with the upper portion of the Ophir shale of the East Tintic Range, and with the middle unit of the Millard formation as defined in the Sheeprock area by Cohenour (1957, p. 49). The top of the sequence is placed at the base of the Bluebird dolomite. The sequence is thought to contain the equivalent of the Teutonic and Herkimer limestones of the East Tintic area, in addition to the upper portion of the Ophir shale. No lithologic unit representative of the Dagmar limestone is present, however. The sequence is approximately correlated with the upper Millard, Burnt Canyon, Dome limestone, Condor formation, Swasey limestone, Wheeler formation, and most of the Marjum of the Sheeprock section.

Fauna.--Two collections were made in the exposed area of the undifferentiated limestone-shale sequence. The first collection, designated C-1 was taken in the green shale strata just below a typical pisolitic limestone located in the first major saddle on the high ridge trending southeast of Sabe Peak. The



specimens were identified by R. Bright, who reports:

Collection C-1

Glossopleura cf. G. producta

The second collection C-2 is listed in the section describing the Upper Cambrian Opex-Ajax formation.

Measured section.--The following section was measured south-eastward along the crest of the high ridge southeast of Sabe Peak. Structural complications and colluvium cover made it necessary to trace conspicuous beds along their strike and to measure the sequence where conditions permitted. The base of the section is taken just above a fault zone in the underlying Tintic quartzite, and the top is just below the first occurrence of the crystalline Bluebird dolomite.

Undifferentiated limestone-shale sequence:

	Feet
23. Dolomite, blue-gray, weathering light-brown to gray, some brecciation. Fault of unknown type and displacement may be present.....	62
22. Limestone, blue-gray with light-brown argillaceous partings, thin-bedded, fine-grained.....	184
21. Limestone, blue-gray, mostly thin-bedded, soft and containing faunal collection C-2 described in the Opex-Ajax section.....	14
20. Limestone, blue-gray, mostly thin-bedded.....	25
19. Dolomite, blue-gray, weathering brownish to light-gray.....	95
18. Limestone, blue-gray, float.....	5
17. Shale, green and brown, float.....	5

16. Dolomite, blue-gray, weathering light-gray, finely crystalline, boundaries of dolomite zone extend across bedding in limestone, in confused fault-fold area.....	30
15. Dolomite, similar to 16, but not faulted.....	4
14. Faulted dolomite, tight folding and brecciation, stratigraphic displacement unknown..	4
13. Limestone, blue-gray, weathering lighter-gray, strongly folded.....	59
12. Shale, olive-green.....	2
11. Limestone, blue-gray, yellowish argillaceous mottling, mostly float.....	18
10. Dolomite, blue-gray, weathering light-gray, finely crystalline.....	9
9. Limestone, blue-gray, thin-bedded, some olive shale partings.....	5
8. Shale, olive-green, mostly float.....	18
7. Limestone, similar to 9, but is dolomitic and somewhat pisolitic.....	21
6. Limestone, similar to 9, but has abundant orange and gray pisolites or <u>Girvanella ellipsoides</u>	37
5. Shale, olive-green, thin beds of limestone, slightly phyllitic and sheared, contains <u>Glossopleura</u> fauna in upper part.....	15
4. Limestone, blue-gray with orange-brown argillaceous blebs and partings, finely crystalline, thin-bedded with shearing parallel to bedding.....	21
3. Shale, phyllitic, calcareous, brown to olive-brown, weathering to same, micaceous shear planes parallel to bedding.....	23
2. Limestone, gray with orange-brown argillaceous mottling.....	24
1. Quartzite, sandy, calcareous, purplish-brown to gray-brown.....	33
Fault zone in Tintic quartzite	
Total undifferentiated limestone-shale sequence..	713

## The Bluebird Dolomite

Distribution and thickness.--The largest exposure of the Bluebird dolomite is in the first, high wooded peak on the southeast-trending ridge south of Sabe Peak. The strata trend northeast across the ridge and turn almost due north in exposures near the eastern base of the same ridge. Smaller exposures crop out along the north side of a ravine about a mile south and southwest of Sabe Peak in the NE $\frac{1}{4}$  sec. 13, T. 10 S., R. 5 W. and north of No Name Road in sec. 22, T. 12 S., R. 4 W.. The measured thickness of the Bluebird is 359 feet.

Lithology.--The Bluebird dolomite consists of a metallic blue-gray, medium-grained crystalline dolomite containing abundant rod-like white dolomite objects averaging about one fourth inch in length. The rods have a random distribution and a twig-like appearance. The Bluebird is generally massive and resistant to weathering. Most fractures and fault zones are silicified.

Age and correlation.--The Bluebird dolomite was identified by its characteristic lithology and stratigraphic position. It was named by Loughlin (Lindgren and Loughlin, 1919, p. 28) from exposures in the East Tintic area. Muessig (1951, table 1) measured 134 feet in the Long Ridge area. The Bluebird is not present to the west in the Sheeprock Range.

The Bluebird dolomite has been described only in the East Tintic area, the Long Ridge area, and in the present area of

investigation. It probably represents a local Middle Cambrian (Morris, 1957, fig. 2) facies deposited under unusual conditions which permitted the preservation of certain uncommon life forms.

Measured section.--The Bluebird dolomite was measured in a southeastward direction along the ridge southeast of Sabe Peak. The base was taken at the lowest exposure of crystalline dolomite, and the top was placed at the base of the first white dolomite bed of the overlying Cole Canyon dolomite.

Bluebird dolomite:

	Feet
4. Dolomite, metallic-dark-blue-gray, weathering medium-dark-gray, massive with indistinct bedding, somewhat broken up and slightly silicified.....	46
3. Fault zone, dolomite, altered to rusty-red and silicified.....	22
2. Dolomite, similar to 4, but with abundant randomly distributed white dolomite rods, and much silica in veinlets.....	148
1. Dolomite, same as 2, but without silica.....	137
Total Bluebird dolomite.....	359

Cole Canyon Dolomite

Distribution and thickness.--The Cole Canyon dolomite appears to conformably overlies the Bluebird at its southern most exposure on the ridge southeast of Sabe Peak. The Cole Canyon exposure on this ridge is located mostly in the NW $\frac{1}{4}$  sec. 20, T. 10 S., R. 4 W.. It has an allochthonous relation to Mississippian strata to the west and south, is bounded on the

north by the Bluebird dolomite, and covered with colluvium to the east. Another exposure of Cole Canyon dolomite lies about one mile northwest in sec. 13, T. 10 N., R. 5 W., where it occurs just south of the Bluebird exposures previously described.

Total thickness of the Cole Canyon in the West Tintic area is not known, but a minimum thickness of 312 feet was measured. Morris (1957, p. 8) measured up to 900 feet of the Cole Canyon in the East Tintic Range, and Cohenour (1957, p. 67) reports a thickness of 899 feet in the Sheeprock area.

Lithology.--The Cole Canyon dolomite in the West Tintic area generally consists of alternating beds of light gray, fine-grained dolomite and dark metallic gray, medium-grained dolomite. Some of the strata are laminated, some are argillaceous, and some contain scattered sand grains. Locally the dolomite contains complex networks of silica veinlets.

Faults and reconstituted breccia zones are present in places. Morris (1957, p. 8) appropriately describes the Cole Canyon as follows:

"The lower 600 feet or so of the Cole Canyon consists of alternating beds of light gray laminated dolomite-----and massive, dusky blue-gray, commonly "twiggy" dolomite resembling the Bluebird dolomite."

Age and correlation.--No fossils were found in the Cole Canyon and correlation with the East Tintic area was made on the basis of lithology and stratigraphic position. The Cole Canyon was



named for exposures in the East Tintic area by Loughlin (Lindgren and Loughlin, 1919, pp. 28-29), and is considered to be the topmost unit of the Middle Cambrian by Morris (1957, fig. 2). The Cole Canyon has been described in the Long Ridge area (Muessig, 1951, table 1), and in the Sheeprock Range where it is mostly limestone (Cohenour, 1957, pp. 67-69).

Measured section.--The Cole Canyon section was measured along the crest of the ridge southeast of Sabe Peak and down its southern slope as far as possible. The base was taken as the lowest light colored, fine-grained dolomite above the Bluebird. The upper contact was not seen in the area, and a covered interval of about 180 feet extends from the upper-most exposure to an approximate fault contact with the Chiulos shale.

Cole Canyon dolomite:

	Feet
10. Dolomite, light-bluish-gray, fine-grained, somewhat fractured and brecciated and has scattered masses of brown-weathering gray jasperoid.....	10
9. Dolomite, similar to 10, but is faintly laminated.....	18
8. Dolomite, similar to 9, but contains scattered sand grains.....	42
7. Dolomite, same as 10, except for the presence of fine silica veinlets in place of jasperoid masses.....	10
6. Weathered colluvial cover, reddish color indicates presence of fault zone.....	6
5. Dolomite, light-bluish-gray, weathering light-gray, rather fine-grained saccharoidal in texture.....	56

4. Dolomite, metallic-blue-gray, weathering dark-gray, somewhat mottled with lighter gray, medium-grained crystalline, rather massive with faint bedding laminae.....	96
3. Dolomite, light-gray, weathering to same, sugary textured.....	6
2. Dolomite, gunmetal-blue-gray, weathering to a lighter blue-gray, medium-grained crystalline, "Bluebird" type in places, scattered breccia zones, some silica boxworks and aggregates, light-gray dolomite in float.....	121
1. Dolomite, light-mouse-gray, weathering about same color, fine-grained, dense, laminated, basal unit.....	3
Total Cole Canyon dolomite.....	368

#### Opex-Ajax (?) Dolomite

General statement.--The identification of Upper Cambrian strata is not conclusive, except in the case of the limestone thrust remnant previously mentioned (see page 38 and unit 21, page 41). Other strata tentatively assigned to Opex-Ajax(?) dolomite are extensively faulted, dolomitized, and silicified. No section was measured because of lack of continuous exposures of unaltered strata.

Distribution.--A small exposure of a thin-bedded limestone occurs on the crest of the ridge southeast of Sabe Peak. The exposure was not mapped, but is situated just southwest of the major southeast trending fault cutting the undifferentiated limestone-shale sequence.

Dolomite strata assigned to the Opex-Ajax(?) occur east of the "Iron" Mine at the north boundary of sec. 24, T. 10 N., R. 5 W.. The contact with the Cole Canyon to the north is inferred, colluvium conceals the strata on the west, and to the east and south the exposures are bounded by faults.

The thickness of the Opex-Ajax formations are reported to be 650 to 1180 feet in the East Tintic area (Morris, 1957, pp. 8-9), and 1950 feet in the Sheeprock Range (Cohenour, 1957, pp. 69, 84).

Lithology.--The limestone exposure on the ridge south of Sabe Peak is thin-bedded and argillaceous, and closely resembles the limestones of the limestone-shale sequence upon which it rests. All other strata assigned to the Opex-Ajax(?) are dolomite, and identification is based on the occurrence of remnant oolitic and pisolitic structures similar to those described by Cohenour (1957, p. 74 and Pl. XVI). The limestone strata were identified on the basis of the contained fauna.

The Opex formation was named by Loughlin (Lindgren and Loughlin, 1919, pp. 29-30) from exposures near the Opex Mine in the East Tintic area. According to Morris (1957, p. 8) the Opex concordantly overlies the Cole Canyon, though possibly separated from it by a slight disconformity. The Ajax limestone was named by Loughlin (Lindgren and Loughlin, 1919, pp. 31-32) in the East Tintic area, who considered it to be of Early Ordovician age, but Morris (1957, p. 9) indicates

that the Ajax has yielded fossils of Late Cambrian age. The Opex and Ajax formations are predominantly limestone in the Sheeprock area (Cohenour, 1957), and dolomite in the Long Ridge area (Muessig, 1951).

Fauna.--The following collection (C-2) was taken on the ridge southeast of Sabe Peak, south of a dolomitized fault zone in the SE $\frac{1}{4}$  sec. 18, T. 10 S., R. 4 W., and just east of the ridge crest. Identification was by R. Bright who reports:

Collection C-2

Pseudagnostus communis  
Pterocephalia sp.  
Oellea sp.  
Linnarsonella (?) sp.  
Iphidella-like brachiopod  
cf. Camaraspoides sp.

According to R. Bright (1957, personal communication) this fauna is representative of the upper part of the Elvinia zone, and probably indicates the presence of the Opex formation.

LOWER AND MIDDLE ORDOVICIAN

General Statement

The lower contact of the Ordovician system was not recognized in the West Tintic area, and the upper contact could not be determined on either faunal or lithologic evidence. The Pogonip, Kanosh, and Swan Peak units are described in this

section. The Fish Haven and Laketown dolomites are combined in an undifferentiated unit, and are described in the section treating the Upper Ordovician and Silurian.

### The Pogonip Formation

General statement.--The Pogonip of the West Tintic area is treated as a formation rather than a group, because the various formations which constitute the Pogonip elsewhere are not recognizable. Exposures are limited, but it is probable that the greater portion of the Pogonip group is present under the widespread Quaternary cover.

Distribution and thickness.--Pogonip strata are exposed near the West Tintic intrusion in the southwest portion of the mapped area. The strata are inclined to the west, overturned, and trend generally northeast. Limestone tentatively assigned to the Pogonip is present in a small exposure at the head of a northeast-trending ravine in the eastern portion of sec. 23 T. 9 S., R. 5 W.. Another exposure of probable Pogonip crops out in a small area about one half mile east of the "Iron" Mine near the west boundaries of secs. 18 and 19, T. 10 S., R. 5 W..

The Pogonip was not measured in the area, but Cohenour (1957, Pl. XX) measured 2018 feet of the Pogonip group in the Sheeprock area. Morris (1957, p. 9) lists the lower Ordovician Opohonga limestone as 400 to 1000 feet thick in the East Tintic



area. Thus, the total original thickness of the Pogonip in the West Tintic area is probably between 1000 and 2018 feet.

Lithology.--The Pogonip strata exposed in the West Tintic mining district consist of bleached and recrystallized limestone and minor dolomite. Colors range from gray to light gray to blue-gray, with yellowish elongate streaks of argillaceous material.

The smaller exposures in the West Tintic Range are thin-bedded gray limestone containing yellowish argillaceous partings between the beds.

Age and correlation.--The Pogonip was identified on the basis of stratigraphic position and lithology. In the West Tintic mining district the exposure occurs stratigraphically below metamorphosed shale and quartzite that resemble the Kanosh shale-Swan Peak quartzite sequence as seen in the Sheeprock Range. The unmetamorphosed strata present in the West Tintic Range are lithologically identical to the Juab limestone in the Sheeprock area as described by Cohenour (1957, p. 96), who proposed a modified correlation with the Pogonip group of the Ibex area (L. F. Hintze, 1951, pp. 38-41).

No fossils were found in the Pogonip, but the West Tintic exposures are considered correlatives of the upper (Juab) limestone member of the Pogonip group in the Sheeprocks, the Lower Ordovician Opahonga formation of the East Tintic area (Morris, 1957, p. 9), and the Garden City formation of the Logan area (J. S. Williams, 1948, p. 1135).

## The Kanosh Shale Member of the Pogonip Formation

Distribution and thickness.--The Kanosh shale member of the Pogonip is exposed in the West Tintic mining district where it occurs along the eastern boundary of the metamorphosed Pogonip limestone. Excellent exposures are present east of the ravine extending from immediately west of the old War Eagle shaft northward to the vicinity of the Orient mine. Although there are no other exposures in the area, some scattered green shale float occurs downslope from outcrops of the Swan Peak quartzite north of the Vernon-Lofgren Road in the SW $\frac{1}{4}$  sec. 27, T. 9 S., R. 5 W..

The estimated thickness of the Kanosh shale in the West Tintic district is 200 feet according to Gardner (1954, p. 12). Cohenour (1957, p. 98) measured 205 feet of the Kanosh formation in the Sheeprock area, but states that neither top nor bottom is exposed. An indication of rapid thinning to the north is found in the exposures in the northern part of the West Tintic Range. The Pogonip limestone exposed in sec. 23, T. 9 S., R. 5 W. was traced to within about 40 feet of the base of outcropping Swan Peak quartzite with no indication of the presence of shale.

Lithology.--The Kanosh shale in the West Tintic mining district is metamorphosed to a hard black to olive-brown slaty argillite. Some alternation of argillite and quartzite layers occur near the contact with the overlying Swan Peak.

Age and correlation.--The Kanosh shale was identified by its lithology and stratigraphic position above the Pogonip limestones and below the Swan Peak quartzite. The Kanosh was considered to be late-Early Ordovician in age by L. F. Hintze (1951, pp. 18-19), who named it from exposures near Kanosh, Utah. No fossils were found in the argillites present in the West Tintic area, but a fossil fauna including graptolites and Receptaculites was observed in the Kanosh shale of the Sheeprock Range.

The occurrence of this unit near the Orient mine was discussed by Stringham (1942, p. 271). Gardner (1954, pp. 11-12) considered the shale to be the equivalent of the upper shale member of the Pogonip formation of the House Range. This correlation appears to be correct.

#### The Swan Peak Quartzite

Distribution and thickness.--The largest exposures of Swan Peak quartzite occur in the West Tintic mining district between the War Eagle and Orient mines. Much of the Swan Peak is obscured by debris from the west slope of Brown's Ridge. Small outcrops occur west of the large ravine in sec. 23, T. 9 N., R. 5 W., and north of the Vernon-Lofgren Road in the SW $\frac{1}{4}$  sec. 26 and the SE $\frac{1}{4}$  sec. 27, T. 9 N., R. 5 W.. The latter exposures are limited in extent and their upper and lower contacts are obscure.

About 38 feet of Swan Peak is present in the West Tintic mining district, and the northern exposures in the West Tintic area range from 10 to 38 feet in thickness. Over 450 feet of Swan Peak was observed in the northern portion of the Sheeprock Range. Both the Swan Peak and the underlying Kanosh shale are absent in the East Tintic district, and the eastward thinning of the two units is apparent in the West Tintic area.

Lithology.--The Swan Peak is a medium-grained gray to white quartzite which weathers tan and brown. Alternating shale and quartzite are present near the base, and rare fucoidal structures were observed.

Age and correlation.--The Swan Peak quartzite was identified by lithology and stratigraphic position in the West Tintic area. The Swan Peak formation as originally defined by R. J. Ross (1949, p. 478), from a study of exposures in northwestern Utah, includes all the strata above the Garden City limestone and below the Upper Ordovician dolomites. In northwestern Utah, the Swan Peak consists of an upper quartzite member and a lower fossiliferous shale sequence. According to L. F. Hintze (1951, p. 21) a similar lithologic relation occurs in central Utah where the Kanosh shale has a fauna and lithology similar to the lower Swan Peak of the type area.

The Swan Peak quartzite of the West Tintic area is Middle Ordovician in age, and is correlated with the much thicker Swan Peak of the Sheeprock Range. It is the approximate age

equivalent of the quartzite portion of the Swan Peak in northwestern Utah, as well as the Swan Peak in the Ibex Hills area of Utah according to Webb (1956, p. 23).

## UPPER ORDOVICIAN AND SILURIAN STRATA

### General Statement

Upper Ordovician and Silurian strata consist of the Fish Haven and Laketown dolomites in the West Tintic area. The lower contact of the Fish Haven is concealed, except in the altered exposures of the West Tintic mining district, and the contact of the Fish Haven and Laketown could not be determined. Thus, the Fish Haven and Laketown are described in this section as an undifferentiated unit.

A section (see Appendix "A") was measured in the West Tintic mining district by Gardner (1954, p. 13), who described 1280 feet of Fish Haven and 945 feet of Laketown, and notes that the contact is arbitrary and subject to refinement.

### Fish Haven-Laketown Dolomite Undifferentiated

Distribution and thickness.--There are several exposures of Fish Haven-Laketown dolomite in the area of investigation, the largest of which occurs in the West Tintic mining district, and along the east side of the West Tintic Range in the northern part of the mapped area. Southeast of the West Tintic mining



district near the southern end of the West Tintic Range, a number of exposures of Fish Haven-Laketown dolomite occur as thrust remnants on the Mississippian Chiulos shale. Other small klippen are present on the slopes of Maple Peak. Two outcrops are present in the hill about one mile southeast of the Bennion Ranch. Other exposures are shown on Plate I.

Only 773 feet of undifferentiated Fish Haven-Laketown dolomite were identified and measured during the present study. Gardner (1954, p. 13-14) measured a total of 2220 feet in the West Tintic mining district, and Cohenour (1957, pp. 105, 112) described approximately 1706 feet of two formations in the Sheeprock Range.

Lithology.--The Fish Haven-Laketown dolomite of the West Tintic district is a dark to medium-gray crystalline dolomite. It is commonly bleached nearly white and contains scattered tremolite <sup>and</sup> wollastonite aggregates. Chert and jasperoid occur at random intervals in bands parallel to the bedding. The uppermost 945 feet (Gardner, 1954, p. 14) is a lighter medium gray, and contains a much higher proportion of chert. Much of the chert is a distinctive pink color and is found associated with Silurian fossils in the northern portion of the West Tintic Range.

The dolomite in the thrust remnants are largely reconstituted breccia, and identification is based on the abundant pink chert which seems characteristic of the Laketown dolomite.

The Fish Haven exposures in the northern portion of the mapped area are characteristically a dark crystalline dolomite with an abundant Halysites fauna. The upper or Laketown portion of the unit is characterized by a lighter gray dolomite and abundant chert.

Age and correlation.--The Fish Haven dolomite is Late Ordovician in age (Richardson, 1913), whereas the Laketown dolomite at the type area in northeastern Utah has been assigned to the Middle Silurian. The Fish Haven-Laketown dolomite is correlated with the Fish Haven and Laketown dolomites in the Sheeprock Range, and are also approximately equivalent to the Fish Haven and part of the Bluebell dolomite of the East Tintic area, and to the Fish Haven and Laketown dolomites of the Logan area (J. S. Williams, 1948, pp. 1137-1138).

Fauna.--A small collection of fossils was made in the Fish Haven-Laketown dolomite approximately along the east-west boundary between secs. 12 and 13 and secs. 11 and 14 in T. 9 S., R. 5 W.. The corals are mostly preserved in pink and brown cherts while brachiopod outlines occur in the dolomite. Dr. W. L. Stokes assisted in the identification.

Collection C-3

Crinoid columnals  
Stromatoporoids  
Favosites favosus  
Halysites several specimens  
Pentamerid brachiopods

Other scattered specimens of Halysites were found in the Fish Haven-Laketown dolomites west of McIntyre Mountain. Also, one specimen of Favosites favosus was collected on the ridge-top about one third of a mile west of McIntyre Mountain.

Measured section.--The Fish Haven-Laketown dolomite section was measured in a westerly direction approximately along the section boundary described under the previous heading. The lower contact of the Fish Haven is covered by colluvium and alluvium, and the upper contact of the Laketown is similarly obscured.

Fish Haven-Laketown dolomite:

	Feet
16. Dolomite, dark-gray, weathering to light-gray, fine-grained, laminated, thin-bedded; some elongate pink chert elliptical masses along bedding.....	23
15. Dolomite, medium-gray, weathering to a medium-light-gray, fine-grained; silica veinlets, no chert.....	60
14. Dolomite, reddish-gray, weathering to a pinkish-blue-gray, fine-grained; locally folded and faulted.....	78
13. Dolomite, dark-gray, weathering same, medium-grained crystalline; small irregular masses and rods of white dolomite. Some brown and black chert.....	22
12. Dolomite, similar to 13, but extremely cherty; strata are very resistant and rough weathering; crinoid columnals and <u>Halysites</u> abundant.....	64
11. Dolomite, similar to 13, large <u>Halysites favosus</u> .....	80
10. Chert zone, pink chert in beds and elongate lenticular masses parallel the bedding of the gray, crystalline dolomite. In places the chert comprises almost 100% of the strata.....	90

9. Dolomite, medium-gray and rather coarsely crystalline.....	14
8. Dolomite, dark-gray, weathering to mottled lighter gray, medium-grained crystalline; much brown chert.....	42
7. Dolomite, similar to 8, but contains scattered pink chert blebs and masses.....	24
6. Dolomite, dark-gray, weathering light- to medium-gray. Sugary texture, some Stromatoporida(?) outlines.....	40
5. Dolomite, very dark-gray, weathering same, fine- to medium-grained; much chert. <u>Halysites</u> and vague outlines of pentamerid brachiopods in dolomite.....	36
4. Dolomite, colluvial cover.....	54
3. Dolomite, similar to 5, but some white chert. <u>Halysites</u> and <u>Stromatoporida</u> s in chert.....	52
2. Dolomite, dark gray, weathering same, medium-grained, slightly laminated, some chert; somewhat brecciated, mostly covered.....	32
1. Dolomite, similar to 2, but not brecciated.....	62
Total exposed Fish Haven-Laketown dolomite.....	773

## DEVONIAN SYSTEM

### General Statement

The Devonian system in the West Tintic is represented by more than 1784 feet of laminated dolomite strata with quartzite and argillaceous limestones in the upper portion. Four distinct formations are present in the area: the Upper Silurian(?) - Lower Devonian Sevy dolomite, the Middle Devonian

Simonson dolomite, the Upper Devonian Victoria quartzite, and the Upper Devonian-basal Mississippian(?) Pinyon Peak limestone. These formations are not exposed in stratigraphic continuity, and it was necessary to measure the sections in several different areas. The Sevy and Simonson dolomites were mapped as one undifferentiated unit as the contact is nowhere exposed.

### The Sevy-Simonson Dolomite

Distribution and thickness.--Several exposures of the Sevy-Simonson dolomite are in the West Tintic area. The largest and least altered exposure is in the northern portion of the mapped area where the north-trending strata of the Sevy-Simonson dolomite lie unconformably below the basal Madison limestone. Continuous outcrops in this area are few and the Simonson dolomite is mostly covered. Exposures of the Simonson in the northwestern part of sec. 23, T. 9 S., R. 5 W. were more suitable for measuring. Another large exposure of Sevy-Simonson is in the West Tintic mining district where it crops out near the base of the east slope of Brown's Ridge and on the west slope of the hill east of Scotia Gulch. Sevy-Simonson exposures in the hill east of the Bennion Ranch are silicified and altered, but are recognizable on the basis of lithology. "J" Hill, north of the Dry Ranch and just east of Vernon Creek near the Tooele-Juab County boundary consists of Sevy-Simonson



dolomite thrust over Mississippian Humbug strata. Other areas of exposure are shown on Plate II.

It was not possible to measure a complete section of the Sevy-Simonson dolomite, though 1216 feet of strata are exposed. Gardner (1954, pp. 18-19) measured 1130 feet of Sevy-Simonson in the West Tintic mining district, and Cohenour (1957, pp. 119, 121) measured a maximum thickness of 1607 feet of the two dolomites in the Sheeprock Range.

Lithology.--The Sevy dolomite is uniformly a light gray, very fine-grained, finely laminated rock, with scattered sand grains and a few sandy beds. The Simonson dolomite is distinguished by its laminated alternating dark and light dolomite beds. Fossil outlines of the brachiopod Atrypa are present in the Simonson, but none occur in the Sevy.

Much of the Sevy-Simonson dolomite exposed in the area has been faulted and brecciated with attendant silicification and iron staining.

Age and correlation.--The Sevy and Simonson dolomites were originally described and named by Nolan (1935, pp. 18-19) from exposures in Sevy and Simonson Canyons in the Deep Creek Range of western Utah. Nolan considered the Sevy and Simonson to be Middle Devonian age, and cited a "pronounced unconformity" between the Laketown and Sevy dolomites. Osmond (1956, p. 1915, fig. 2) assigns a "Siluro-Devonian age" to the Sevy and a Middle Devonian age to the Simonson.

The Sevy-Simonson dolomites are approximate time equivalents of the same units in the Deep Creek and Sheeprock areas, and of the upper portion of the Bluebell dolomite of the East Tintic area. The Simonson is the approximate time equivalent of the Jefferson(?) dolomite of the southern Oquirrh Range as described by Gilluly (1932, pp. 20-21).

Fauna.--No fossils were collected from either the Sevy or Simonson, but outlines of Atrypa type brachiopods were seen in the Simonson formation.

Measured section.--The following section of the Sevy dolomite was measured westward and down section along the ridge top in the northern half of sec. 14, T. 9 S., R. 5 W.. Approximately 780 feet of light gray dolomite colluvium covers the upper portion of the Laketown and the lower portion of the Sevy. The upper contact with the Simonson dolomite is also covered.

Sevy dolomite:

	Feet
12. Dolomite, float, pinkish-gray, very fine-grained; measured westward to approximate position where dark gray dolomite float predominates.....	85
11. Dolomite, pinkish-gray, weathering to a lighter pinkish-gray, very fine-grained faintly laminated, faint bedding.....	48
10. Sandstone, dolomitic, pinkish-gray, weathering brown. Sand grains appear well rounded.....	2
9. Dolomite, light gray, very fine-grained, faintly laminated; silica veinlets.....	28

8. Dolomite, medium gray, weathering to bluish-gray; sandy streaks appear and disappear along the strike.....	37
7. Dolomite, medium gray, weathering to a slightly bluish light-gray, very fine-grained, laminated; silica in fractures and joints.....	28
6. Dolomite, light mouse-gray, weathering to a creamy light-gray, otherwise similar to 7.....	106
5. Dolomite, with alternating sandy dolomite beds from one inch to two feet thick; dolomite is characteristic aphanitic, light pinkish-gray, the sandy layers weather brownish-gray.....	122
4. Dolomite, pinkish-gray, weathering lighter, very fine-grained, somewhat broken up and fractured.....	54
3. Dolomite, reddish weathering to pinkish-gray, very fine-grained; some faulting.....	14
2. Dolomite, sandy, light pinkish-gray with sand grains, the rock weathers brownish-gray. Petrographic examination shows the sand grains to be about .1 mm to .3 mm in mean diameter. They are sub-rounded with a low degree of sphericity and randomly oriented. Scattered veinlets of disseminated hematite accounts for the pink color and indicate hydrothermal action.....	4
1. Dolomite, light pinkish-gray, very fine-grained, laminated, folded and faulted; much colluvial cover.....	74
Total Sevy dolomite measured.....	602

The following section of the Simonson dolomite was measured eastward across the exposure from top to base in the northwest part of sec. 23, T. 9 S., R. 5 W.. The base of the Simonson and most of the underlying Sevy are obscured by dolomite float, and very little of the upper contact and overlying Victoria quartzite are exposed.

Simonson dolomite:

Feet

21. Dolomite, gunmetal blue-gray, weathering to a mottled medium-gray, medium-grained crystalline, abundant irregular silica veinlets poorly exposed. Upper contact is first dolomitic sandstone of Victoria.....	40
20. Covered interval, ravine with bedrock obscured by alluvium and colluvium.....	74
19. Dolomite, same as 21.....	138
18. Dolomite, gunmetal blue-gray, weathering to mottled dark-gray, medium-grained crystalline; complex network of silica veinlets. Outlines of <u>Atrypa</u> type brachiopods appear on weathered dark surfaces.....	28
17. Dolomite, mostly dark-gray, weathering to a laminated effect of lighter and medium-gray; scattered veins of white crystalline dolomite....	34
16. Dolomite, dark gunmetal-gray, weathering to a slightly pinkish light-gray, very fine-grained, fine laminations; much brecciated silica along irregular fracture planes.....	16
15. Dolomite, gunmetal-gray, weathering to a mottled medium-gray, rather fine-grained; random occurrences of small white dolomite objects, brown-weathering silica veinlets.....	8
14. Dolomite, black, nearly black weathering, fine-grained, laminated, brown-weathering; silica veinlets.....	12
13. Dolomite, medium-gray, weathering light-gray, medium-grained, laminated, clastic appearing.....	2
12. Dolomite, dark gunmetal-gray, weathering to medium-gray, medium-grained crystalline, laminated; a few beds of clastic origin composed of fossil fragments, very fetid.....	12
11. Dolomite, gunmetal-gray, weathering to light pinkish-gray, medium-grained crystalline, faintly laminated; brown-weathering silica veinlets.....	4
10. Dolomite, colluvium, mixed dark- and light-gray..	30



9. Dolomite, black, weathering to mottled dark-gray, faintly laminated, extremely fetid.....	8
8. Dolomite, metallic dark-gray, weathering to medium-gray, laminated; several 2 to 4 inch beds are obviously clastic and consist of unrecognizable fossil fragments.....	24
7. Dolomite, alternating thick beds of dark-gray and light-gray dolomite; light-gray type is fine-grained, both are laminated.....	72
6. Dolomite, dark-gray, weathering to medium-gray, medium-grained crystalline; minor silica.....	14
5. Dolomite, black, weathering to a mottled very dark-gray; irregular small masses of dark-brown chert or jasperoid, brown silica veinlets..	16
4. Dolomite, dark-gray, weathering lighter gray, medium-grained crystalline, faintly laminated; some brown-weathering silica veinlets.....	20
3. Dolomite, covered interval.....	20
2. Dolomite, outcrop, dark-metallic-gray, weathering to pinkish-medium-gray, medium-grained crystalline; brown silica veinlets and scattered jasperoid masses.....	12
1. Dolomite, float, dark-metallic-gray, weathering to a medium-gray with slight pinkish tint.....	32
Total exposed Simonson dolomite.....	614
Total exposed Sevy-Simonson dolomite.....	1216

### The Victoria Quartzite

Distribution and thickness.--The Victoria quartzite is seen at three localities in the West Tintic area. In the West Tintic mining district, steeply dipping, slightly northeast-trending strata are exposed near the crest of the ridge just east of Scotia Gulch and extend northward near the abandoned



Allah shaft. The Victoria crops out in a faulted synclinal pattern in the McIntyre Mountain area, and a few small exposures occur in the northern portion of the area just west of the measured Simonson section.

A maximum thickness of 118 feet of Victoria quartzite was measured on the east flank of the McIntyre Mountain syncline. Gardner (1957, p. 19) measured 50 feet of equivalent quartzite in the West Tintic district (see Appendix "A").

Lithology.--The Victoria exposed in the West Tintic mining district and in the McIntyre Mountain area is a light-gray to tan, medium-grained quartzite, but the limited exposures in the northern area and the West Tintic district display bedding and cross-bedding, whereas the McIntyre Mountain exposures are massive.

Age and correlation.--The Victoria quartzite was named by Loughlin (Lindgren and Loughlin, 1919, pp. 38-39), and subsequent studies by the U. S. Geological Survey (Morris, 1957, p. 13) have established its Late Devonian age. Cohenour (1957, p. 124) measured 736 feet of Victoria and Pinyon Peak strata, but did not differentiate them. Arnold (1956, p. 21) reports several thick quartzite units in the Stansbury formation of Upper Devonian age in the northern Stansbury Range. Though no fossils were found, the position above the Simonson indicates Late Devonian age.

The Victoria quartzite is equivalent in age to the Victoria quartzite of the Sheeprock Range and the East Tintic Range. It is also correlative with part(?) of the Stansbury formation of the northern Stansbury Range, and to the lower part of the Guilmette formation of Gold Hill district (Nolan, 1935).

This quartzite unit was referred to by Stringham (1942, p. 271) as the Allah quartzite. Gardner (1954, p. 16) accepted Stringham's nomenclature and refers to the quartzite as "The Allah quartzite member of the Guilmette formation". It is recommended that the name Allah quartzite be dropped in favor of the Victoria quartzite.

Measured section.--The Victoria quartzite was measured in a westerly direction across the east flank of the McIntyre syncline in the area of best exposure. The underlying Simonson dolomite is highly silicified, and the contact with the Pinyon Peak limestone is obscured by quartzite debris.

Victoria quartzite:

Feet

1. Quartzite, pinkish-white and light-gray to tan, weathering tan and brown. Medium-grained, silica cement shows scattered free grains--indicating possible silicification of an original dolomitic quartzite. Somewhat shattered with local breccia zones present, quartzite thickens and thins along the strike.....	118
Total exposed Victoria quartzite.....	118

## The Pinyon Peak Formation

Distribution and thickness.--The Pinyon Peak formation is exposed in the West Tintic mining district along the east slope of the ridge east of Scotia Gulch, and in the vicinity of the Pyramid mine. The best exposures, however, are in the east flank of the McIntyre syncline north of McIntyre Mountain.

The Pinyon Peak has a minimum thickness of 450 feet in the McIntyre syncline area.

Lithology.--Pinyon Peak strata in the West Tintic mining district consist of light blue-gray weathering, platy limestone, which becomes siliceous and dolomitic westward. The Pinyon Peak strata exposed in the McIntyre syncline consist of a uniform, thin-bedded, medium-gray, argillaceous limestone. The argillaceous material is commonly tan, yellow, or reddish brown. Crinoid columnals are abundant, but other fossils are fragmentary and difficult to identify.

Age and correlation.--The Pinyon Peak was named by Loughlin (Lindgren and Loughlin, 1919, p. 36) from exposures on Pinyon Peak in the East Tintic area. On the basis of fossil evidence the U. S. Geological Survey has dated the formation as Late Devonian and early Mississippian(?) (Morris, 1957, p. 13). The writer has tentatively identified a Cladopora(?) specimen from near the base of the Pinyon Peak and an outline of a Euomphalid(?) type gastropod from near the top of the exposed

section which would seem to indicate that the upper part is of Mississippian age. The Pinyon Peak strata of the West Tintic area correlate with those of the East Tintic area and the Sheeprock Range. The Pinyon Peak is the approximate age equivalent of the upper portion of the Stansbury formation of the northern Stansbury Range (Arnold, 1956).

Measured section.--The Pinyon Peak section was measured westward across the east flank of the McIntyre syncline from the approximate contact with the Victoria quartzite to the highest Pinyon Peak strata present.

Pinyon Peak formation:

	Feet
4. Limestone, gray, weathering lighter-gray with yellowish-brown argillaceous partings, thin-bedded, platy, scattered outlines of Euomphalid type gastropods.....	69
3. Limestone, same, somewhat sheared and with brown silica veinlets.....	73
2. Limestone, gray, weathering to mottled light-brown and gray with argillaceous partings and blebs, platy, fine-grained, thin-bedded, crinoid fragments abundant, some brachiopod fragments.....	174
1. Limestone, similar to 2, except fossil fragments rare.....	134
Total Pinyon Peak exposed.....	450

## THE MISSISSIPPIAN SYSTEM

### General Statement

The Mississippian System is represented in the West Tintic area by 3275 feet of strata, including five and possibly six formations. These formations are the Pinyon Peak formation of Devonian-Mississippian age, the Madison limestone, the Deseret formation, the Humbug formation, the Great Blue limestone with the thick Chuilos shale-quartzite member, and possibly the Manning Canyon shale. The Pinyon Peak formation, which apparently bridges the Mississippian-Devonian boundary has been described with the Devonian system, and although the presence of the Manning Canyon shale is suspected, no positive evidence was found. The Deseret and Humbug formation are mapped as a unit because of their similar lithologies.

### The Madison Limestone

Distribution and thickness.--The Madison limestone disconformably overlies the Devonian Sevy-Simonson dolomite in the northern portion of the West Tintic Range, where much of the Paleozoic section is overturned and apparently allochthonous in nature. The Madison exposure is bounded on the north by a thrust plane, and extends southwestward nearly three miles to form much of the crest of this part of the range. Two exposures occur in the southeastern portion of the mapped area where the Madison



crops out in association with other Mississippian formations, and a small exposure of Madison(?) appears on a ridge in sec. 26, T. 11 S., R. 5 W. to the east of the area of Paleozoic exposures in the West Tintic mining district.

The Madison in the northern exposure is 719 feet thick, which compares favorably with a measurement of 623 feet in the northern Sheeprock Range, and 900 feet in the West Tintic area.

Lithology.--The Madison limestone is a fine-grained fossiliferous limestone with beds averaging about one foot in thickness. The lower portion is silty, whereas the upper portion is characterized by nodules and layers of dark-gray and tan-weathering chert. A few bioherms of crinoid and other fossil fragments, and at least one thin sandstone layer were observed in the upper portion. White calcite veins normal to the bedding are abundant, and secondary dolomitization has affected parts of the Madison in the southeastern exposures. The topographic expression of the Madison is determined by structural relations rather than lithology, though the cherty upper portion is a potential ridge former.

Age and correlation.--The Early Mississippian Madison limestone was named by Peale (1893) for exposures in the Madison Range of Montana. Lithologic similarity to the Madison in adjacent areas, stratigraphic position, and presence of Spirifer centronatus, served to identify the formation in the West Tintic area.

The Madison overlies Devonian strata with an erosional unconformity representing all or parts of the Pinyon Peak, Victoria quartzite, and Simonson dolomite. The period of erosion is pre-Madison, but may not be pre-Mississippian.

The Madison limestone of the West Tintic area is correlative with the Madison of the Sheeprock Range, the East Tintic area, in other Utah areas, and in areas northward through Idaho to Montana.

Fauna.--Madison collections were identified by W. L. Stokes, Walter Sadlick, and the writer.

Collection C-4 was taken from the Madison exposure in sec. 9, T. 12 S., R. 4 W. in the southeastern portion of the West Tintic Range.

Spirifer centronatus  
Euomphalus sp.  
Lithostroton cf. L. whitneyi  
Triplophyllites sp. (several)  
Various unidentified cup corals  
Syringoporid corals  
Crinoid columnals

Collection C-5 was taken from the large northern exposure along the course of the measured section in sec. 11, T. 9 S., R. 4 W.. Fossils were collected at scattered intervals and are listed from the base upward.

Euomphalus sp.  
Syringoporid corals  
Crinoid columnals (very abundant)  
Triplophyllites sp. (mostly small, average one inch  
in length)  
Chonetid brachiopod  
Spirifer centronatus

Measured section.--The Madison limestone was measured in an easterly direction from the top downward along a fairly prominent ridge to the south of the main saddle in the northern part of the West Tintic Range in sec. 11, T. 9 S., R. 4 W.. The disconformable contact with the underlying Sevy-Simonson dolomite is largely obscured by thick colluvium on the rather steep eastern slope. The base of the Madison was selected at the point where gray dolomite ceases to occur in the colluvium, and the top was drawn where the first fine-grained, fetid, and thin-bedded strata characteristic of the overlying Deseret-Humbug units are observed.

The Madison limestone:

	Feet
13. Limestone, dark blue-gray, weathering to lighter blue-gray with light-gray mottling, fine-grained, average bedding thickness 2 feet; <u>Spirifer centronatus</u> found in this horizon. Colluvial cover may obscure a fault(?) of unknown displacement.....	41
12. Limestone, similar to 13, but with 1 to 3 inch bands of gray- to brown-weathering black chert with nearly regular 12 inch spacing intervals, abundant crinoid columnals and traces of small horn corals.....	20
11. Limestone, blue-gray, weathering lighter blue-gray, medium-grained, chert banding similar to 12, abundant crinoid columnals and traces of small horn corals.....	40
10. Limestone, gray, soft, with abundant fenestellid bryozoans.....	12
9. Limestone, similar to 11, but has fenestellid bryozoans, <u>Triplophyllites</u> , <u>Spirifer centronatus</u> and crinoid columnals.....	46
8. Sandstone, calcareous, light-brown-weathering.....	1

7. Limestone, similar to 11, but with chert bands being replaced by a dense black limestone. White calcite veins are common; a specimen of <u>Spirifer centronatus</u> found in this horizon.....	188
6. Limestone, blue-gray, weathering lighter, narrow chert bands and elongate blebs, white calcite in veins normal to bedding.....	82
5. Limestone, similar to 6, reddish calcite in random veins, some contortions.....	17
4. Limestone, same as 6, but red calcite veins are rare, and the interval is mostly covered with Madison colluvium.....	98
3. Limestone, similar to 6, but red calcite veins abundant.....	78
2. Limestone, dark-blue-gray, with reddish tint, weathering to a slightly pinkish lighter-blue-gray, reddish-brown fracture fillings, fairly coarse, clastic, with a few bioherms 6 to 8 inches thick composed almost entirely of fossil fragments.....	56
1. Limestone, float, gray, weathering slightly pinkish with red veins and fracture filling indicating the proximity of faulting.....	20
Total <u>exposed</u> Madison limestone.....	645

#### Deseret-Humburg Formations Undifferentiated

Distribution and thickness.--The Deseret-Humburg unit has several exposures in the West Tintic area. The largest and best of these is in an area about three miles long just west of the Madison limestone in the northern part of the West Tintic Range. Two other large exposures occur in association with the Madison in the southeastern foothills of the West Tintic Range.

The thickness of the Deseret-Humbug unit, as measured in the northern portion of the area, is 803 feet, but this may be incomplete. Morris (1957, p. 15) found 1775 feet of the combined formations in the East Tintic area, and Cohenour (1957, table 1) gives their combined thickness in the Sheeprock Mountains as 1564 feet.

Lithology.--The Deseret-Humbug unit consists of alternating layers of limestone and calcareous sandstone, which thicken and thin along strike. The upper (Humbug) portion contains more sand than the lower (Deseret) portion, but chert is abundant in the thin-bedded sequences of the Deseret and virtually absent in the Humbug. The chert occurs in narrow bands which locally grade into calcareous sandstone bands along the strike.

Silicification has spread outward from major faults converting the sandstones to quartzite and the limestones to jasperoid. The quartzites, thus formed, are resistant and often form wall-like topographic features.

A characteristic platy brown-weathering black sandy limestone containing small white siliceous concretions occurs near the middle of the unit. Sedimentary quartzite facies occur sporadically in the lower portion. A phosphatic, calcareous shale normally found near the Madison-Deseret contact was not identified in the West Tintic area.



Age and correlation.--The Deseret formation was named by Gilluly (1932, p. 25) for exposures at the Deseret mine in the southern Oquirrh Range of Utah. The Humbug formation was named by Tower and Smith (1899, pp. 625-626) from exposures near the Humbug tunnels in the East Tintic area. The overall lithologic similarities to these Late Mississippian formations in adjacent areas, plus the stratigraphic position conformably above the Madison limestone and conformably below the Great Blue limestone served to identify the formations in the West Tintic area. Fossils found in the unit served to support the identification, though only one form is diagnostic.

Fauna.--Fossils collected from the Deseret-Humbug formations are mostly external molds or fragments.

Collection C-6 was taken near the northern faulted terminus of the unit in sec. 2, T. 9 S., R. 5 W.. Identifications were made by Walter Sadlick, as follows:

"Fragment of an orthotetid brachiopod  
External mold of a Torynifera(?)  
Fenestella sp.  
Fragments of a Spirifer  
Rhomboporid  
Fragment of a Brachythyris(?) cf. B. washingtonensis  
Crinoidal columnals of Platyceinites(?)"

Numerous unidentified horn corals were found in this same area, and W. L. Stokes identified an external mold of a brachiopod as:

Dictyoclostus sp.

Collection C-7 consists of a single specimen of Spirifer cf. S. logani which was found about 500 feet SE of C-5, in the lower (Deseret) portion of the unit.

Collection C-8 was taken from the crest of the high hill in sec. 19, T. 10 S., R. 4 W., about half a mile northeast of "J" Hill. Identifications were made by Walter Sadlick, who reports:

"Productid, Antiguatonia(?)  
Chonetes or Rhipidomella  
Spirifer sp.  
Crinoidal columnals  
Large Linoproductus  
Triplophyllites (T.) cf. T. clinatus,  
approximate septal formula C8A10K at about  
18 mm diameter. This species has been  
described by W. H. Easton from the Warsaw  
formation of the type Meramec.  
Caninia(?) horn coral, silicified"

Measured section.--A section of the Deseret-Humburg was measured eastward from top to base across the exposures in the northern portion of the West Tintic Range. Because of abundant cover most of the lower portion was measured in the large saddle in sec. 11, T. 9 S., R. 5 W., and the remainder of the section near the end of the exposure to the north in sec. 2, T. 9 S., R. 5 W..

Contact with the underlying Madison is apparently conformable and is drawn where the thicker-bedded, blue-gray Madison limestone is in contact with fairly thin-bedded dark gray, cherty and locally sandy limestone of the Deseret. The upper contact was drawn at the top of the uppermost sandy limestone bed.

Deseret-Humbug formations undifferentiated:

	Feet
24. Limestone, very sandy, blue-gray, weathering to tan sandy surface; much cover.....	4
23. Limestone, dark blue-gray, weathering lighter; abundant scattered sand laminae, some cross-bedding, scattered horn corals.....	82
22. Colluvial cover, mostly tan-weathering sandstone, with sandy gray limestone.....	20
21. Limestone, dark blue-gray, weathering lighter; light brown sand on some weathered surfaces; white calcite veins, scattered horn corals of various sizes, much cover.....	21
20. Sandstone, calcareous; and limestone, alternate gray-weathering limestone and brown-weathering sandstone, virtually concealed by the colluvial float of predominant sandstone lithology.....	34
19. Sandstone, calcareous, gray-brown, coarse to medium-grained, abundant scattered fossil fragments, usually crinoidal detritus, slight cross-bedding.....	19
18. Limestone, sandy, blue-gray, weathering lighter; mostly covered.....	11
17. Sandstone, calcareous, gray, weathering to gray-brown, medium to coarse-grained, slight cross-bedding; much colluvial cover.....	12
16. Sandstone, pinkish-gray, weathering reddish-tan, some cross-bedding, slightly calcareous.....	8
15. Limestone, sandy, blue-gray, weathering to light brown.....	4
14. Sandstone, light tan-gray, weathering reddish, medium-grained; calcareous in part.....	12
13. Limestone, sandy, gray, weathering purplish; 12-inch beds or less, clastic; crinoidal fragments abundant and large.....	26

12. Sandstone, gray to reddish-gray, weathering red-brown, medium to coarse-grained, silicified, resistant; horn coral bioherm in part, some faulting along bedding.....	6
11. Sandstone, light gray to reddish-gray, weathering to a light reddish-brown, fine-grained, platy, silicified, liesegang banding; Collection C-5.....	20
10. Limestone, sandy, gray, rather coarse-grained, obviously clastic in origin; some 2-inch bands of hard sandstone, slight cross-bedding.....	30
9. Sandstone, calcareous, gray, weathering brown to tan and reddish-gray, platy; abundant fenestellid bryozoans.....	30
8. Limestone, sandy, reddish-gray, weathering to a tan-gray; fenestellid bryozoans.....	19
7. Limestone with much black chert, all occurring as platy colluvial cover east of ridge crest.....	28
6. Sandstone, calcareous, black, weathering to light-brown or purplish-brown, fine-grained, platy; scattered silica concretions(?).....	148
5. Sandstone, quartzite, gray, medium-uniform-grain; lenticular along strike.....	22
4. Limestone, alternating with chert in beds or bands from 2 to 4 inches thick. Limestone is dark-gray and weathers lighter, chert is black and weathers to dark brown and gray, often the chert gives way to tan calcareous sandstone along the strike. This unit is almost solid jasperoid and chert at the northern faulted contact.....	40
3. Limestone, alternating with sandy limestone in 2 to 3 inch beds; sandy beds are sometimes cross-bedded. Unit is distinctive and was traced nearly a mile northward where exposures were improved.....	27
2. Sandstone, quartzitic, gray, weathering to reddish-brown; varies in thickness along strike, may even lense out completely.....	60

1. Limestone, dark-gray, weathering blue-gray, fine-grained, fetid, bedding 1 to 2 inches in thickness; abundant scattered chert bands and blebs; scattered sandy laminae; best available exposures have some tight folds, no fossils, ..... 120
- Total Deseret-Humburg formations undifferentiated. 803

### The Great Blue Limestone Members

General statement.--The name Great Blue limestone may be confusing because many exposures of the unit in the area are not limestone; the Chiulos shale member actually makes up the thickest exposure. The Great Blue is divided into a lower limestone, the Chiulos shale member, and an upper limestone. Separation of the lower limestone from the upper is impractical in exposures where the intervening Chiulos is absent. The Chiulos member is discussed under a separate heading.

Distribution and thickness.--There are many exposures of the Great Blue limestone members in the area. The largest exposures are in the northern and southeastern parts of the West Tintic Range. In the northern part, exposures of the lower Great Blue limestone extend from the northern edge of the mapped area southward for over two miles, and form most of the western flank of the range. Exposures of both lower and upper limestone members occur in the southeast part of the range. Exposures consisting of strata, tentatively identified as the upper limestone member, are in sec. 5, T. 12 S., R. 4 W.



and secs. 31 and 32, T. 11 S., R. 4 W.. Also those occurring in secs. 32 and 33, T. 10 S., R. 4 W., may consist of the upper limestone member (see fossil collection C-14).

Only 483 feet of the lower limestone member was identified and measured in the northern exposure of the West Tintic Range. Neither upper nor lower contacts of the Chiulos member with the limestone members were found. No other measurements were made of the limestone members owing to the lack of stratigraphic continuity and structural complications. Cohenour (1957, table 1) gives the thickness of the lower and upper limestone members as 911 and 1400 feet respectively in the Sheeprock area. Morris (1957, p. 15) has measured a total maximum thickness for equivalent members of 1000 feet.

Lithology.--The Great Blue limestone members consist of a distinctive bluish-gray-weathering limestone in well-defined beds ranging from 4 inches to as much as 20 feet in thickness. The limestone is locally cherty, is mostly clastic in origin, and contains an abundant Faberophyllum fauna. Euomphalid outlines are also common. Topographic expression is predominantly related to structures and the Great Blue occurs both in ridges and depressions.

The Great Blue limestone in the East Tintic area was divided by Morris (1957, p. 20) into four members, which in ascending order are: (1) a basal limestone member about 400 feet thick, (2) a limestone and shale member about 650 feet

thick, (3) a shale and quartzite member 850 to 1000 feet thick, and (4) an upper limestone member about 600 feet thick. Of the foregoing, members 2 and 3 are thought to correspond to the Chiulos member in the West Tintic area, which accounts for the three member subdivision in the latter area and in the Sheeprock Range.

Age and correlation.--The Great Blue limestone was named by Spurr (1895) from the typical "blue" limestone exposures in the Mercur mining district of the southern Oquirrh Range, and its age was established as late Mississippian (Chester) by Girty (Gilluly, 1932, pp. 29-31). The Great Blue limestone was identified, in the West Tintic area, by its lithologic similarities to the Great Blue in nearby areas, its stratigraphic position above the Deseret-Humbug formations, and by its abundant fauna. The altered limestone exposed in the window in sec. 2, T. 10 S., R. 5 W. was tentatively identified by silicified productid spines and a Faberophyllum specimen.

Fauna.--The lower and upper limestone members of the Great Blue contain an abundant fauna. Several collections were made from separate areas as follows:

Collection C-9 consists of two horn coral specimens taken from the Great Blue limestone in the southwest portion of the West Tintic Range in sec. 4, T. 12 S., R. 4 W.. These were identified by Walter Sadlick from polished sections:

"Faberophyllum sp. (lower Great Blue limestone)."

The writer has also identified Euomphalus sp. from this area. Collection C-10 consists of horn corals from the Great Blue limestone outcrop near Cherry Creek Road and northeast of Cherry Creek Reservoir in Sec. 19, T. 11 S., R. 4 W.. Identified by Walter Sadlick from polished sections as follows:

"Faberophyllum sp. (lower Great Blue limestone)."

Collection C-11, from lower limestone of Great Blue exposed in sec. 15, T. 9 S., R. 5 W.. Walter Sadlick reports:

"Paleocoryne sp."

Collection C-12, from east-west line of measured section, just south of the trace of the thrust fault in sec. 2, T. 9 S., R. 5 W.. Identified by W. L. Stokes, who reports:

"Faberophyllum sp.  
Pugnoides cf. P. ottumwa"

Collection C-13, collected from the Great Blue limestone outcropping east of "J" Hill in sec. 29, T. 10 S., R. 4 W.. Identification is by W. L. Stokes and the writer:

Faberophyllum sp.  
Syringopora sp.  
Lithostrotion sp.  
Spiriferella sp.  
Euomphalus sp.

Collection C-14, taken from the Great Blue limestone near McIntyre Ranch in secs. 32 and 33, T. 10 S., R. 4 W.. Identified by Walter Sadlick as follows:

"Striatifera or linoproductus fragments; more suggestive of the former, probably upper portion of the Great Blue limestone."

Measured section.--The section was measured to the west from the top of Humbug in sec. 2, T. 10 N., R. 5 W.. The top of the Humbug is placed at the highest sandy limestone bed which is four feet in thickness. The lower limestone member of the Great Blue conformably overlies the Humbug, but the upper contact with the Chiulos member is covered by alluvium.

The lower limestone member of the Great Blue formation:		Feet
14. Limestone, blue-gray, weathering lighter, much black chert which weathers gray and occurs in short elliptical masses or is elongated along bedding for several feet. Productid brachiopod outlines occur with crinoid and horn coral fragments.....	111	
13. Limestone, sandy, brown weathering; much cover.....	3	
12. Limestone, similar to 14, but less chert; small horn corals, numerous fragments of large brachiopod shells.....	31	
11. Limestone, blue-gray, weathering lighter, medium-grained crystalline, chert in narrow discontinuous bands 0 to 2 inches thick, scattered white calcite veins, medium-bedded, numerous large horn corals ( <u>Faberophyllum</u> sp.)...	60	
10. Limestone, horn coral ( <u>Faberophyllum</u> ) bioherm....	2	
9. Limestone, same as 11, Collection C-12.....	14	
8. Limestone, blue-gray, weathering lighter blue-gray, medium-grained crystalline, abundant veinlets of white calcite, black chert bands up to 6 inches wide lense in and out. ( <u>Faberophyllum</u> sp.).....	60	

7. Limestone, similar to 8, but no chert; some sand present.....	14
6. Limestone, similar to 8, with elongate chert blebs along bedding, thinner beds.....	59
5. Limestone, similar to 8, rare chert in blebs, beds to 10 feet in thickness.....	44
4. Limestone, blue-gray, weathering lighter with some mottling, medium-grained and made up largely of fossil fragments, some sand.....	24
3. Limestone, similar to 4, but fairly fine- grained and fetid; abundant horn corals.....	12
2. Limestone, black, weathering blue-gray, fine- grained, slightly shaly, with abundant Pugnoides brachiopod fauna (C-12).....	3
1. Limestone, blue-gray, weathering to a lighter blue-gray, somewhat mottled; white calcite veinlets in abundance; beds 5 to 20 feet thick; abundant fragmental horn corals and other fossils.....	46
Total exposed lower limestone member of Great Blue....	483

## The Chiulos Shale Member of the Great Blue Limestone

General statement.--The Chiulos shale member of the Great Blue has thus far been described only in the East Tintic Range, in the Sheeprock Range, and in the present area of investigation. As its lithology is unique and known occurrence limited, the Chiulos member is worthy of individual consideration. It is possible that certain areas of shale mapped as Chiulos may be Manning Canyon. This is especially true in the small exposure near the north end of the mapped area.





Devils Gate looking southward. A steep-walled canyon cut by Devils Creek through a silicified fault zone dividing the Chiulos member of the Great Blue on the left (east) from the Deseret-Humbug unit on the right. The high rhyolite flow-breccia ridge east of the Maple Peak anticline is in the right foreground.

Distribution and thickness.--The Chiulos shale member is exposed in several localities in the West Tintic Range, east of Vernon-Cherry Creek Valleys. The largest areas of exposure are near the southern terminus of the range and in the area north of Maple Peak.

The total exposed and estimated thickness of the Chiulos member in the West Tintic area is 1404 feet. Both upper and lower contacts of the Chiulos are obscure, and tight folding renders measuring on a long traverse unreliable. As much as 2000 feet of Chiulos may be present in the area; Gardner (1954, p. 22) measured 1140 feet along the Cherry Creek-Eureka Road, Cohenour (1957, table 1) cites a minimum of 1818 feet in the Sheeprock Range, and Morris (1957, p. 15 and fig. 4) reports that shaly, sandy, silty, and quartzite members of the Great Blue in the East Tintic area have a maximum thickness of 1000 feet.

Lithology.--The Chiulos shale member is dominantly a black fissile shale, though brown-weathering olive shales are present. Some of the shale, especially the brown-weathering variety, contains concretions and rare external molds of conispiral gastropods. Fossiliferous limestone beds of various thicknesses are distributed throughout parts of the shale sequence. Near the middle of the Chiulos member a thick series of alternating quartzite, shale, and siltstone is present. The lower quartzite is medium-grained, tan to brown weathering

and resistant. The higher quartzite is blue-gray-weathering, and is characterized by numerous white quartz veins and brown limonitic flecks on a medium blue surface when freshly broken. The siltstones are olive green and much softer than the quartzites.

In most exposures the Chiulos is seen to be tightly folded with the shattered and silicified quartzite beds standing as resistant remnants above the subdued topography characteristic of shale bedrock.

Petrography.--In thin section the blue-gray quartzite appears to be silica cemented, fine-grained and slightly argillaceous. The grains are sub-rounded, and scattered masses of limonite are present.

The olive-green Chiulos is a fine-grained quartzite or siltstone with about 30 percent argillaceous material in the interstices. The green color of the argillaceous material is evident in plane polarized light.

Age and correlation.--The Chiulos shale member of the Great Blue limestone was named by Morris (1957, p. 21) from exposures in Chiulos Canyon in the East Tintic Mountains. Identification of fauna from the Chiulos shale shows it to be of Chester age which agrees with the age of the Great Blue as reported by Gilluly (1932).

The Chiulos member of the Great Blue is correlated with the same member in the Sheeprock Range and in the East Tintic

district. Walter Sadlick (1958, personal communication) interprets the Chiulos as a tongue of the Chainman shale (Spencer, 1917, pp. 26-27), though he admits there is little evidence for this interpretation.

Fauna.--An abundant fauna was collected on the south bank of the Utah Highway 36 road cut near the northern edge of the mapped area. This assemblage was examined by Walter Sadlick who reports as follows:

Collection C-15

"Rhipidomella, small form  
Cleiothyridina (crushed)  
\*Spirifer leidy  
Buxtonia(?) n. sp.  
\*Orthotetes sp.  
Composita sp.  
Mooreoceras(?)  
\*Reticularina spinosa, small form  
\*Punctospirifer cf. P. Transversa  
Chonetes  
Linoproductus(?) small form with coarse rugae  
New genus aff. Echinoconchus  
Batostomellid bryozoans  
Cystodictya sp. (not Sulcoretopura)  
Antiquatonia sp.

The entire assemblage would be placed by most paleontologists as a Chester equivalent; the most significant forms are asterisked."

Measured section.--The Chiulos section was measured westward across the east flank of the Maple Peak anticline in sec. 8, T. 11 S., R. 4 W.. The contact with the upper limestone member is covered and the 600 feet of shale, traversed before reaching the first quartzite outcrop, is estimated, as it is characteristically covered with a dark loose soil and outcrops

are absent. The basal contact of the Chiulos with the lower limestone member was not found in the core of the anticlinal structure.

Chiulos shale member of the Great Blue limestone:

	Feet
15. Shale, mostly black and fissile; area well covered, other lithologies undoubtedly present; estimated thickness to Tertiary rhyolite cover.....	600
14. Quartzite, gray; weathering tan, gray, and brown; much limonite staining; medium-grained, hard and resistant.....	46
13. Quartzite, blue-gray, weathering to lighter blue-gray (resembles limestone from a distance) fine-grained; brown limonite spots on fresh surface; many white quartz veins.....	30
12. Siltstone or fine-grained argillaceous quartzite (see petrography) olive-green, rather soft.....	22
11. Shale, black, fissile, mostly covered by colluvial material; some seams of greenish siltstone and brownish limestone present.....	29
10. Quartzite, blue-gray, weathering lighter, medium to fine-grained; brown limonite masses on fresh surface (see petrography).....	51
9. Shale, black, with thin seams of olive-green siltstone.....	20
8. Quartzite, blue-gray, slightly mottled with brown limonite, weathers brown, medium- to fine-grained.....	27
7. Shale, black, mostly covered in topographic low.....	118
6. Quartzite, blue-gray with brown spots on fresh surface, weathers lighter, medium- to fine-grained.....	27
5. Quartzite, mostly gray with brown streaks, fine-grained.....	84



4. Shale, covered.....	32
3. Quartzite, sandy, blue-gray, weathering lighter; brown limonite stain on fracture surfaces; resembles limestone; white quartz veins.....	12
2. Quartzite, soft, silty, olive-green, weathering brownish, fractured.....	32
1. Shale, black, mostly covered, somewhat contorted; in core of anticline.....	280
Total exposed and estimated Chiulos.....	1404

## THE PENNSYLVANIAN SYSTEM

### General Statement

The Pennsylvanian system is represented only by the lower limestones and sandstones of the Oquirrh formation, which are the youngest Paleozoic rocks in the area of investigation. A much thicker section of Oquirrh was observed in that portion of the West Tintic Range extending north of the mapped area.

### The Oquirrh Formation

Distribution and thickness.--Oquirrh strata are exposed at only two places in the West Tintic area.

Low rounded hills in the northwest portion of the mapped area are formed of Oquirrh limestone and sandstone beds which strike north and are nearly vertical. These hills are designated herein as the "East Vernon Hills", and are

accessible from Utah Highway 36 about two miles east of Vernon. A smaller exposure crops out in secs. 5 and 6, T. 11 S., R. 4 W., about half a mile north of the Eureka-Cherry Creek Road.

The measured thickness of the Oquirrh exposed in the East Vernon Hills of the West Tintic area is 2227 feet.

Lithology.--The Oquirrh consists of alternating beds of fossiliferous limestone and sandstone of various thicknesses. A lower limestone unit several hundred feet thick occurs on the east side of the East Vernon Hills. Colluvial material weathering from the Oquirrh formation has a characteristic brown color and much of the sandstone is cross-bedded.

Age and correlation.--The Oquirrh formation was named by Gilluly (1932, p. 34) for extensive exposures in the southern Oquirrh Range of Utah. It was identified in the West Tintic area on the basis of both lithology and fauna. The age of the Oquirrh strata based on faunal evidence is probably Early Pennsylvanian (Morrow and Springer).

Fauna.--The Oquirrh contains an abundant fauna and several collections were made as follows:

Collection C-16, taken from the sandstone and limestone strata along the west side of the East Vernon Hills.

The collection was identified by Walter Sadlick as follows:

"Batostomellid bryozoan  
Syringoporida coral  
Linoproductus n. sp. aff. L. brazeiaus  
Paladin sp. (trilobite pygidia)  
Antiquatonia(?) sp.  
\*Reticularina spinosa large form, not seen higher  
than Morrow  
Echinoconchus sp.  
Composita sp.  
\*New genus cf. Productus arkansanus Girty  
Orbiculoidea sp.  
\*Neospirifer cf. cameratus  
Jurensania sp.  
Caninia sp.  
Polypora sp.  
Fenestella sp.  
Pinneritopora sp."

The writer has identified Chaetetes sp. from the  
same area.  
(\* indicates diagnostic forms)

Collection C-17 was taken from exposures in secs. 5 and 6,  
T. 11 S., R. 4 W.. Identification by W. L. Stokes  
(Gardner, 1954, p. 24):

"Schizophoria texana  
Linoproductus cf. L. prattenianus  
Chonetes sp.  
Spirifer rockymontanus  
Spirifer occidentalis  
Dictyoclostus cf. D. hermosianus  
Buxtonia(?)  
Composita(?)

This assemblage indicates early Pennsylvanian  
age appropriate to the lower Oquirrh formation."

Same area--identification by Walter Sadlick.

"New genus aff. Diaphragmus phillipsi  
Dictyoclostus aff. inflatus  
Linoproductus aff. form "d", n. sp.

Probably collected near base of the Oquirrh  
formation, not more than 500 feet above the top  
of Manning Canyon shale."

Collection C-18 was taken just beyond the north edge boundary of the mapped area, north of the east-west fault in sec. 35, T. 8 S., R. 5 W.. Identification by Walter Sadlick:

"New genus aff. Buxtonia  
Triplophyllites spinosa  
Composita cf. C. magnus Newall  
Composita cf. C. subtilita  
Wellerella n. sp. aff. W. osagensis  
Derbia n. sp.

This collection probably Springer or Morrow in age and probably represents a horizon in a limestone unit near the base of the Oquirrh."

Collection C-19 was taken near the middle of the East Vernon Hills on a measuring traverse (see measured section). Identified by W. L. Stokes as follows:

Spirifer cf. S. rockymontanus  
Spirifer cf. S. occidentalis

Other fossils from the same location were identified by Walter Sadlick, who reports:

"Schizophoria aff. resupinoides  
Linoproductus sp.  
Spirifer cf. occidentalis  
Antiquatonia cf. coloradoensis

Schizophoria is similar to form considered very low Pennsylvanian."

Collection C-20 was taken from east of center of East Vernon Hills. Identification by Walter Sadlick, as follows:

"Spirifer pellaensis-occidentalis stock;  
Pennsylvanian form  
Linoproductus sp.  
Spirifer cf. occidentalis  
Antiquatonia cf. coloradoensis"

Schizophoria is similar to form considered very low Pennsylvanian."

Collection C-21, near east side of East Vernon Hills, on line of measuring traverse (see measured section). Identifications were made by W. L. Stokes and the writer.

Cleiothyridina orbicularis  
Composita cf. C. subquadrata  
Hustedia sp.  
Productids, unidentified

Measured section.--The Oquirrh section was measured eastward along the main divide in the portion of the East Vernon Hills situated in secs. 3 and 4, T. 9 S., R. 5 W.. No indication of the lower contact of the Oquirrh with the Manning Canyon shale was found. If the Manning Canyon is absent in the West Tintic area, it is possible that a gradational contact between the basal limestone of the Oquirrh and the upper limestone member of the Great Blue is present. However, should the latter case be true, the paucity of fossils in the eastern portion of the East Vernon Hills prevented its recognition. It is assumed, therefore, that the base of the Oquirrh lies east of the exposed area and is covered by the unconsolidated fill which surrounds the greater part of the East Vernon Hills, and forms the upper boundary of the measured section.

Oquirrh formation:

Feet

20. Limestone, alternating with sandstone.  
Limestone color ranges from gray to light-brown on weathered surface; sandstones



Feet

- are mostly calcareous and weather to a light-brown, are medium-grained, and often show large scale cross-bedding. A few chert blebs and bands occur along the bedding. These strata are fossiliferous and most of the assemblage in collection C-16 came from unit 20. The exposures are all on the west slope of the East Vernon Hills..... 686
19. Limestone, gray, weathers gray to lighter-gray, rough irregular surface, beds one inch to a foot in thickness, thin cherty seams and sandy laminae, resistant, forms western crest of East Vernon Hills; no fauna..... 120
  18. Limestone, gray, coarsely crystalline, fossiliferous; location just east of resistant north-south trending ridge. Chaetetes sp., Echinoconchus sp., and various Linoproductids present in area; see collection C-16, which contains a fauna collected from this point to end of exposure westward..... 26
  17. Colluvial cover, mostly platy, light-brown calcareous sandstone in topographic saddle..... 94
  16. Mostly colluvial cover, with light-brown-weathering sandstone predominating, scattered limestone outcrops near top, no fauna..... 132
  15. Limestone, sandy, gray, weathers gray to light-brown, some scattered cherty blebs in lower portion, abundant unidentified linoproductid zone, crinoid fragments also present..... 94
  14. Sandstone, quartzite, gray, weathering light-brown, uniform medium-grained..... 30
  13. Limestone, sandy, weathers gray-brown, medium- to coarse-grained..... 26
  12. Sandstone, quartzite, light-brown, weathering darker brown..... 12
  11. Limestone, sandy, gray, weathers to light gray-brown, platy; contains some 4-foot beds of more massive blue-gray limestone with scattered white calcite veins, scattered Derbyia brachiopod shell fragments..... 70

10. Sandstone, calcareous, light-gray, weathering to light-brown.....	29
9. Limestone, medium-dark-gray, weathering to medium-light-gray, fine-grained, slightly sandy; scattered dark gray elongate chert blebs.....	60
8. Colluvial cover, consisting of quartzitic sandstone with some sandy limestone, scattered outcrops of sandy limestone and sandstone.....	224
7. Limestone, medium-gray, weathering to a light and darker-gray mottled effect; elongate pinkish-gray chert blebs along bedding, becomes lighter-gray and slightly sandy near base; scattered crinoid columnals, syringoporid tubes, and curved outlines of Linoproductid brachiopods.....	48
6. Limestone and sandstone in alternating beds of varying thickness, bedding well developed, some beds with scattered chert, some without chert; limestone usually gray, sandstone weathers to light-brown.....	146
5. Limestone, gray, weathering lighter, sandy; gray-brown-weathering chert in small masses usually elongate parallel to bedding, some brecciation and scattered fragments of black chert; fossil collection C-18 taken approximately 28 feet from top.....	78
4. Sandstone, light gray, weathering brown, somewhat calcareous.....	8
3. Colluvial cover, sandstone and limestone.....	42
2. Sandstone, calcareous, brown weathering.....	4
1. Limestone, gray, weathering lighter-gray, irregular gray-brown chert blebs, well bedded, abundant fragments of horn corals indicate clastic origin, fossil collection C-21 taken near top.....	298
Total exposed Oquirrh formation.....	2227

## MESOZOIC(?) SYSTEM

### General Statement

The only Mesozoic sedimentary unit in the West Tintic area is an unnamed greenstone which was mapped as questionable Cretaceous or Tertiary. The greenstone is described under the Mesozoic system in this paper, but later studies may establish its age as Tertiary.

### The Unnamed Greenstone

Distribution.--Small exposures of the unnamed greenstone occur in what is apparently a fenster in the Precambrian allochthon northeast of the mouth of Little Valley and mostly in sec. 2, T. 10 S., R. 5 W.. The strata are mostly covered by colluvium and soil, but the greenstone apparently rests unconformably on the autochthonous Great Blue(?) limestone.

Lithology.--The unnamed greenstone is a green, rather coarse grained clastic rock. It is fairly thin-bedded, contains much magnetite, and is somewhat porous and friable.

Petrography.--A petrographic examination showed the greenstone to consist of clastic subrounded grains of plagioclase, potash feldspar, pyroxene, magnetite, volcanic glass, jasperoid, and a green nodular mineral tentatively identified as celadonite. The cementing matrix is hydrothermal(?) calcite which embays

many of the plagioclase grains. The larger plagioclase grains are labradorite, and the pyroxene is in the augite-diopside range.

The presence of unzoned labradorite and pyroxene is indicative of a diabasic intrusion as a possible partial source of origin for the greenstone (John Hower, 1958, personal communication). According to Bronson Stringham (1957, personal communication), the mineral celadonite is often a product of propylitization in extrusive rocks. Thus, the overall composition and nature of the greenstone indicates that it is a fluvial deposit formed of debris from source rocks which included a diabasic intrusion and an altered andesite flow.

Age and correlation.--The age of the unnamed greenstone is most likely latest Cretaceous (Montana) or earliest Tertiary (Paleocene). The greenstone strata appear to lie below a part of the Precambrian allochthon, and may be considered pre-thrust in age. Laramide thrusting is thought to have occurred in Late Cretaceous (Montana) time (Eardley, 1951, p. 325). However, the andesitic debris in the greenstone may indicate a Tertiary age because Cretaceous extrusive rocks have not been previously identified in the region.

The unnamed greenstone may be a local facies of either the North Horn or Flagstaff formations which exist at least as far west as Long Ridge (Muessig, 1951, pp. 74-76). Identification of the Green River formation in the area may be taken as supporting evidence for such a tentative correlation.

## TERTIARY SYSTEM

### General Statement

The Tertiary system is represented in the West Tintic area by the Wasatch(?) and Green River formations, and the Salt Lake group. These units were not measured due to lack of continuous exposures. Fossils identified as Green River were found at one locality and the strata from which these came were mapped as Green River. However, somewhat similar strata which may actually be Green River yielded no fossils. These could not be precisely dated and were mapped more generally as the Salt Lake group.

### The Wasatch(?) Formation

Distribution and thickness.--The conglomerates of the Wasatch(?) formation are in secs. 5, 6, and 8, T. 11 S., R. 4 W., around the perimeter of the large exposure of the Chiulos member of the Great Blue limestone north of Maple Peak. All of the exposures rest unconformably on underlying strata, and most of them are partially covered by Tertiary rhyolite. The best exposure is seen north of the Cherry Creek Road about one-fourth mile west of Devils Gate.

Lithology.--The Wasatch(?) formation present in the West Tintic area is a conglomerate composed of angular limestone boulders, cobbles, and pebbles in a red-calcareous matrix. The larger



portion of the conglomeratic material is quite angular, and resembles talus blocks up to two feet in diameter. Smaller particles are more rounded. The conglomerate material resembles Great Blue or Oquirrh limestone.

Age and correlation.--The conglomerate unit was given the name "Devils Gate conglomerate" by Gardner (1954, p. 25), who assigned it a tentative Late Cretaceous age. The name Wasatch(?) is applied to the conglomerates, and a tentative early Tertiary age is assigned to them for the following reasons: (1) the profound unconformity at the base of the unit; (2) the lithologic similarity to the Paleocene Wasatch conglomerates of the Wasatch Range, and to the Flagstaff conglomerates of probable Wasatch equivalence in the Long Ridge, Utah, area; and (3) an apparent unconformable stratigraphic position below strata identified as Green River.

The Wasatch conglomerate cannot be positively correlated with any other conglomerate in the eastern Great Basin, but the following conglomerates have similar positions in the stratigraphic column or have similar lithologies: the Flagstaff conglomerate of the Long Ridge area (Muessig, 1951, p. 74); the unnamed Eocene(?) conglomerates of the East Tintic area (Morris, 1957, p. 26); and the Wasatch equivalent sediments occurring along the east flank of the Stansbury Range (Thomas, 1946, pp. 109-110).

## The Green River Formation

Distribution and thickness.--One small exposure of essentially horizontal Green River strata crops out in the West Tintic area. The exposure is north of the Cherry Creek-Eureka Road in sec. 32, T. 10 S., R. 4 W., and is easily viewed from the road about one mile west of McIntyre Ranch. Other strata of a similar lithology are present in the same vicinity and extend southward along the eastern flank of the West Tintic Range for a distance of six miles. Evidence to differentiate between the Green River and the overlying Salt Lake units is lacking. Future studies may show that the Green River is more extensive in the area.

No measurements were made of the thickness of the Green River, but it is estimated that several thousand feet of combined Green River and Salt Lake strata are present.

Lithology.--The small exposure of Green River strata consists of shaly beds of soft tan calcareous lutite with such an abundance of large ostracodes (to 2 mm.) that the rock could be called an ostracod shale.

Age and correlation.--The Green River strata in the West Tintic area, were identified by the ostracod fauna. Wood (1941, Pl. 1) gives the age of the Green River as Middle Eocene. Muessig (1951, pp. 79-88) has described the occurrence of the Green River formation in the Long Ridge area about 20 miles southeast

of the West Tintic Range, where it conformably overlies the Flagstaff formation and is well identified by fossils.

The strata identified in the West Tintic Range represent the western-most occurrence of the Green River formation. Stokes (1957, personal communication) has suggested that the Green River Lake had a westward outlet to the sea.

Fauna.--The following listed collection was taken from the previously described outcrop of the Green River formation:

Collection C-22 was identified by D. L. Jones (1957, written communication) as follows:

"Lithologically, it (the rock specimen submitted) is a finely laminated calcilutite with abundant valves and entire carapaces of non-marine (probably lacustrine) ostracods. The following ostracods have been identified:

Cyprois cf. marginata  
Cyprois n. sp. (Swain, 1956)  
Cyprois pagei (Swain)  
Limnocythere sp. (Swain)

These species are found in the Green River-Colton transition beds of East-Central Utah."

### The Salt Lake Group

Distribution and thickness.--Strata of the Salt Lake group are for the most part covered by pediment gravels and residual or transported alluvium in the West Tintic area. Exposures occur in road cuts (Pls. VIII and IX), quarries, gully walls, and isolated hills in many places along the eastern and northeastern borders of the mapped area. Geologic boundaries as indicated are somewhat indefinite.

Exposures near the central part of the West Tintic Range and along the eastern flank in the more southern portion of the range may be in part Green River. This was pointed out previously.

An isolated exposure occurs in a road cut just north of the bridge over Vernon Creek in sec. 9, T. 9 S., R. 5 W.. This exposure is a partially cemented fanglomerate, and may be near the top of the Salt Lake group. Another isolated outcrop consisting of tuffaceous marl occurs just north of the Jerico Road in secs. 17 and 18, T. 12 S., R. 4 W..

The Green River(?) - Salt Lake group underlies the Pleistocene pediment gravels throughout most of the north-eastern, eastern, and southeastern portions of the mapped area. Cemented fanglomerates underlie much of the colluvium in the Little Valley area and these are considered to belong to the Salt Lake formation.

No measurements of the Green River-Salt Lake formation were attempted. However, it is probable that several thousand feet of the two units exist in the mapped area and in Tintic Valley to the east. Kreek (1957, personal communication) measured several thousand feet of Salt Lake strata across Rush Valley five miles north of the mapped area.

Lithology.--The strata mapped as Salt Lake in the West Tintic area consist mostly of marly limestone and bentonitic tuffs. Some of the tuffs are unaltered, and some produce a greasy,



A.--Tuffaceous strata in the Salt Lake formation exposed in an east facing terrace near the southern boundary of sec. 9, T. 9 S., R. 4 W.. View is to the northwest.



B.--West-dipping Salt Lake strata exposed in a road-cut about one mile northwest of Wild Bill's. View is toward the north.



bentonitic residual material in the near-surface weathered zone. The colors mostly range from white to brownish-yellow, though weathered bentonic clays are almost any color. Silt, sand, and gravel are present in increasing amounts upward. Fanglomerates, such as the exposure near the Vernon Creek Bridge, are thought to be near the top of the Salt Lake formation.

The exposures in sec. 14, T. 10 S., R. 4 W., near Boulter, contain considerable amounts of silicified material. This would seem to indicate Quaternary hydrothermal or hot spring silicification.

The Salt Lake strata are soft and weather rapidly, except where they are made resistant by silicification or are protected by overlying gravel (Pl. IX, B).

Age and correlation.--The Salt Lake group was first named by Hayden (1896, p. 92) for exposures in the Weber and Salt Lake Valleys. No fossils were found in the Salt Lake formation of the West Tintic area and identification and correlation of the unit was made on the basis of lithology and stratigraphic position. Morris (1957, pp. 26-28) has described the Salt Lake(?) formation in the Boulter Pass area, and has provisionally correlated it with the Salt Lake formation of Pliocene age as exposed in Jordan Narrows south of Salt Lake City (Slentz, 1955b, pp. 28-29). The overall age of the Salt Lake group may range from Oligocene thru Pliocene (Slentz, 1955b). Actually, the evidence present in the West Tintic area is insufficient to



A.--North-dipping Salt Lake strata exposed in a railroad-cut in sec. 7, T. 9 S., R. 4 W.. The strata consist of tuffs and marls.



B.--Weathered and bentonitic Salt Lake formation material below pediment gravel. Photo was taken near the inferred Salt Lake-pediment gravel contact in sec. 35, T. 11 S., R. 4 W..

determine the age of the Salt Lake, except as being post mid-Eocene (age of the Green River) to pre-Pleistocene.

### Tertiary Travertine

A deposit of travertine has been quarried along the west flank of the West Tintic Range in sec. 35, T. 8 S., R. 5 W. where Utah Highway 36 crosses the range. The travertine was apparently deposited by hot springs issuing from faults or fissures. The travertine cannot be precisely dated, but is probably related to Basin and Range faulting of Late Tertiary age.

### QUATERNARY SYSTEM

#### General Statement

Unconsolidated deposits of Quaternary age cover the greater portion of the West Tintic area. The abundance of these deposits seriously hampers the study of bedrock geology, but is of significance when considering the Quaternary history of the West Tintic Range.

Gilbert (1890, Pl. XIII) indicates that Pleistocene Lake Bonneville occupied much of Rush Valley north of the mapped area, and Kreek (1957, personal communication) has noted Bonneville sediments in Rush Valley about five miles north of Utah Highway 36. However, the entire West Tintic area is higher than the Bonneville shoreline.

The unconsolidated Quaternary deposits have been divided into three classifications as follows: (1) Pleistocene pediment gravels, (2) Recent colluvium or slope wash, and (3) Recent undifferentiated alluvium and aeolian deposits.

### Pleistocene Pediment Gravels

General statement.--The material mapped as Pleistocene pediment gravels includes some gravels which were not deposited on a pediment surface, but which may have filled topographic lows on the pre-gravel surface. Some of the gravels may have been deposited in great thicknesses on the down-thrown side of normal faults.

Distribution and thickness.--A study of the geologic map (Pl. I) shows that unconsolidated gravels surround the higher portion of the West Tintic and Sheeprock Ranges. They largely obscure the flanking bedrock and lie on a sloping dissected pediment surface, which bevels the underlying Green River(?) - Salt Lake strata in the northeastern, eastern, and southeastern portions of the area.

Exposures of gravel east of Vernon Creek near the mouth of Little Valley, and relatively high-level exposures in secs. 19, 20, and 29, T. 10 S., R. 4 W., near the center of the West Tintic Range are especially interesting. These deposits indicate that the unconsolidated gravels once extended over a much larger portion of the area, and that the bedrock

core of the West Tintic Range is presently being stripped of such deposits. It is notable that the gravel is composed of rock types unlike those of the bedrock in the present uphill areas.

The thickness of the Pleistocene gravels ranges from a thin cover to an estimated 200 to 300 feet in the high area situated about three miles west of Boulter and north and south of the Tooele-Juab County line. The thickness cited is estimated from the depth of ravines (Pl. X), and may indicate that a thick bajada was formed on the down-thrown side of a Basin and Range fault in this locality. Following deposition of the gravel and pedimentation, general uplift of the West Tintic Range, faulting, and accelerated erosion separated the bajada from the main mountain mass, and dissected the pediment. Slentz (1955a, p. 30) describes a similar sequence of events along the eastern front of the Oquirrh Range.

Lithology.--The pediment gravels are chiefly composed of resistant subangular to rounded fragments of Precambrian quartzite, tillite, and slate. Rounded pebbles of green fuchsite quartzite from the tillite matrix are rarely present. A portion of the gravels consists of jasperoid fragments with subordinate dolomite and limestone of Cambrian lithology. Quartzite and jasperoid fragments range from sand size to boulders larger than an automobile, which according to Marsell (1957, personal communication) were probably transported by





Aerial photo showing a portion of the dissected high-level pediment gravels in secs. 16, 17, and 21, T. 10 S., R. 4 W.. The pediment surface has been incised to a depth of 200-300 feet. The view is to the southwest across the central part of the West Tintic Range and the southern portion of the Sheeprock Range. The Desert Mountains are in the background. The topographic low area just west of the dissected pediment surface is thought to be due to Pleistocene(?) faulting, alteration, and subsequent erosion.

mud flows. None of the characteristic argillaceous lubricating material of mud flows could be found in the vicinity of the large blocks, but seasonal rains could easily wash such material away.

Age and correlation.--The pediment gravels are considered to be of Pleistocene age because of: (1) unconsolidation, (2) deposition on a surface which in places truncates the Green River-Salt Lake strata, (3) the occurrence of an orange-red loessic material which apparently underlies the gravels in the deep ravines in sec. 8, T. 12 S., R. 4 W., and (4) the presence of basaltic cobbles and boulders near the outer extremities of some of the dissected gravel ridges in the southern part of the area. In the latter case, the basaltic eruptions of the region are considered as late in the regional igneous sequence (Butler, et al., 1920, p. 89).

Eardley (1955, p. 43) believes that the process of pedimentation began in Pleistocene time in north-central Utah, and considers the pediment surfaces to have been dissected in pre-Lake Bonneville time. Slentz (1955b, p. 34) in discussing the Oquirrh foothills pediment, provisionally dates the pedimentation stage as the latest Pliocene or early Pleistocene. A Pre-Bonneville age for the West Tintic pediment gravels is favored and they are tentatively correlated in time with the gravel veneer of the Oquirrh foothills pediment.

## Recent Colluvium

Colluvial cover or slope wash often obscures the bedrock geology in the West Tintic area. Colluvium has been mapped where its presence renders the geological interpretation of the underlying bedrock impractical.

## Undifferentiated Alluvium and Aeolian Deposits

Much of the West Tintic area is covered by alluvium, which is usually confined to high and low-lying valley flats, to stream courses and to dry washes. Most of the material is fluviatile, but there is a fairly high proportion of aeolian deposits. A large area of dune sands occurs to the south in Sevier Desert. The dune sands are encroaching northeastward into the southern part of the mapped area, and small wind-formed sand heaps are present in the area of investigation.

Some of the alluvium mapped in the northern portion of the area is very fine-grained and argillaceous. It is thought to have been derived from the weathering of the underlying Salt Lake strata, and some of the area mapped as alluvium may be the weathered surface of the Salt Lake group.

## IGNEOUS ROCKS

### GENERAL STATEMENT

Both extrusive and intrusive igneous rocks are present in the West Tintic area. The extrusive rocks are the more extensive, and are particularly abundant in the southern portion of the mapped area. Remnants of extrusive rocks occurring in such high areas as Maple Peak, suggest that much, if not all, of the area was covered by extrusive material in pre-Salt Lake time.

A large volcano, similar to the one identified in the East Tintic Range by Morris (1957, p. 29), may have dominated the terrain in the southern West Tintic area in early Tertiary time. Extrusive material essentially buried the then existing dissected and structurally complex West Tintic Range and adjacent eastern flank of the Sheeprock Range. The conduits or eruptive centers are now covered by younger sedimentary deposits or colluvium, but pyroclastic materials have been observed as fissure fillings in sedimentary deposits and at least one volcanic plug is present in the area.

The extrusive rocks are divided into six groups as follows:

1. Precambrian(?) diabasic flow(?) rock;
2. Late Paleocene(?)-Eocene rhyolite;

3. Eocene andesite porphyry;
4. Eocene andesites;
5. Eocene andesitic pyroclastics;
6. Pliocene-Pleistocene(?) basalt.

Intrusive rocks in the area are: (1) the West Tintic monzonite stock, and (2) a later granite stock(?) which was eroded and later buried by the andesite porphyry in the southern portion of the West Tintic Range. Small granite cupolas(?), believed related to (2), have intruded the monzonite and sedimentary rocks of the West Tintic mining district. Some of the rhyolite exposures may be of intrusive origin (see p. 131), and several dikes occur in the West Tintic mining district. The dikes were not studied in the field and were not mapped. However, Stringham (1942, pp. 274-280) has discussed the dikes, other igneous rocks, and contact relations in the West Tintic mining district.

Complete analyses and classification of all the igneous rocks in the area was not attempted, though minor occurrences of other extrusives are associated with the andesites. Types, other than those discussed may be present; but, only a division into the major groups is considered to be within the scope of the present problem.

Identification of rock types is based on examination in the field and on a petrographic study of thin sections from selected specimens.



## EXTRUSIVE ROCKS

### Precambrian(?) Diabase

Distribution.--Diabasic rock crops out at the head of Little Valley in secs. 21 and 28, T. 10 S., R. 5 W., where it occurs in the lower quartzite unit of the Sheeprock series (see p. 16). A similar association is present in a small exposure at the Blackhawk mine in Little Valley. Faulting and colluvial cover are present in both areas, and geologic interpretations are difficult. Diabase float was observed near the base of the quartzite ridge just northeast of Chicken Rock in the NW $\frac{1}{4}$  sec. 21, T. 11 S., R. 5 W.. The presence of a diabasic rock, is also indicated somewhere near the area of exposure of the unnamed greenstone because of the presence of pyroxene and zoned labradorite grains (see p. 97).

Description and petrography.--The diabase is brown on weathered exposures and dark-olive-green on fresh surface. The diabasic texture is easily recognized in hand specimen.

Thin section studies of specimens taken from the exposure at the head of Little Valley and from the vicinity of the Blackhawk mine showed the rock to have a typical diabasic texture with lath-shaped plagioclase (labradorite?) in a matrix of altered pyroxene and magnetite and some secondary quartz.

Age and correlation.--The diabase is thought to be an inter-bedded Precambrian flow near the top of the lower quartzite unit. Its extrusive origin is suspected from its restriction to essentially the same stratigraphic horizon throughout the area. Cohenour (1957, pp. 153-154) describes the diabase as "a sill that is definitely pre-folding in age and is, therefore, pre-Tertiary." If it is considered as intrusive in nature, then a possible correlation with the much more recent diabase dikes and sills of the East Tintic Range (Morris, 1957, p. 39) is indicated. However, a Precambrian (pre-Dutch Peak tillite) age for the diabase is favored herein because a few diabase pebbles were observed in the tillite.

#### The Paleocene(?) - Eocene Rhyolite

Distribution and description.--Rhyolite is exposed in numerous localities in the West Tintic area. The largest exposures occur in the central part of the West Tintic Range. Rhyolite crops out here as purplish flow breccia in the high ridge, northeast of Maple Peak and a porphyritic type is exposed north and west of Maple Peak. Partially silicified rhyolite forms most of the north-trending ridge south of "J" Hill. Bleached and altered rhyolites and interbedded acid tuffs occur east of this ridge in a continuous sequence of an estimated 1000 feet or more in thickness.

Rhyolite is exposed in the northern part of the mapped area along Utah 36 east of the West Tintic Range, several out-

crops along the eastern flank of the range, east and south of the East Vernon Hills, and east of Bennion Ranch. In this area, the rhyolite is mostly a buff to pinkish colored rock with abundant quartz phenocrysts. Obsidian, vitrophyre and tuff is associated with the rhyolite in the Bennion Ranch area.

Altered rhyolite occur in the "Iron" Mine area in the NW $\frac{1}{4}$  sec. 13, T. 10 S., R. 5 W.. Other altered rhyolites are present about a half mile east of the "Iron" Mine, and silicification has altered an entire rhyolite ridge to a dense white jasperoid. In hand specimens of the latter, only the original quartz phenocrysts remain recognizable.

Porphyritic rhyolite in the vicinity of Chicken Rock may be intrusive (see p. 131). Small exposures of rhyolite in the West Tintic area is indicative of a much greater original extent of rhyolite deposits.

Petrography.--The porphyritic rhyolites are similar in megascopic appearance, except for variations in color, grain size, and amount of alteration.

Rhyolites from the northern portion of the West Tintic Range, the vicinity of Sabe Peak, and the vicinity of McIntyre Mountain have a similar appearance in hand specimen and thin section. In thin section a typical specimen shows phenocrysts of quartz and potash feldspar (sanidine) with minor plagioclase, biotite, magnetite, and some amphibole in a matrix forming 60 percent of the slide. The matrix consists of semidevitrified

brown glass with abundant trichites. Zeolite (palagonite) spherulites are developed in fissures and outward from the edges of fractured feldspar phenocrysts. Swirling flow structure is present, and most of the phenocrysts are fractured by viscous flow. Quartz phenocrysts are larger, and many are embayed or corroded by the matrix.

Specimens taken from south of the East Vernon Hills differ from the preceding description, in that the matrix is less devitrified and spherulites are absent. Streaks of obsidian were observed in hand specimen.

The rhyolite of the large central exposure shows porphyritic, fessite, flow breccia, and tuffaceous phases. The porphyritic type is petrographically similar to the preceding description, except that secondary silica is present.

Rhyolite in the vicinity of Chicken Rock resembles other porphyritic rhyolites in the area in hand specimen, but differs in petrography. The phenocrysts are about 50 percent quartz, 30 percent potash feldspar, 15 percent plagioclase, and 5 percent biotite with chlorite and magnetite. The matrix constitutes about 50 percent of the thin section, and is a fine crystalline aggregate of sericite, plagioclase(?) and quartz. Most of the phenocrysts are fractured, divided, and corroded, and those of quartz are much larger.

Age and correlation.--The rhyolite sequence is considered the oldest of the extrusive rocks in the area. It rests upon an

eroded surface of Paleocene(?), Paleozoic, and Precambrian rocks in the central portion of the West Tintic Range, and apparently dips under the Green River-Salt Lake strata (Pl. II, sec. C-C').

According to Morris (1957, p. 30) the oldest effusive rock in the East Tintic Range is the Packard quartz latite. Muessig(1951, pp. 98-99) dated a series of andesite agglomerates, which are younger than the Packard, as middle Eocene. The basis for Muessig's dating is a flora from the overlying Sage Valley limestone of the Long Ridge area.

The West Tintic rhyolite sequence is the approximate time equivalent of the Packard quartz latite of the East Tintic Range. It post-dates thrusting in the area, and is probably pre-middle Eocene in age.

#### Eocene Andesite Porphyry

Distribution and description.--Exposures of andesite porphyry are limited to the southern portion of the West Tintic Range where they occur in the Nipples Peaks and form conspicuous rounded outcrops over an area of more than one square mile. The porphyry also occurs near the southern terminus of the range where it is largely covered by pediment gravels.

The andesite porphyry has large, white phenocrysts in a greenish groundmass. It resembles an intrusive rock, both in grain size and mode of weathering, but, according to Bronson



Stringham and Max Erickson (1957, personal communication), the porphyry is definitely a flow rock.

In hand specimen, the andesite porphyry consists of euhedral plagioclase phenocrysts as much as half an inch in length in a greenish-gray aphanitic matrix containing abundant crystals and flakes of dark amphibole and bronze biotite.

Petrography.--A typical specimen of andesite porphyry examined in thin section shows the andesine phenocrysts averaging about 9 mm in mean diameter and making up 50 percent of the thin section. Some phenocrysts are corroded by the matrix which consists of a finely crystalline aggregate of sericitized feldspar. Some phenocrysts are fragmental and a few have oscillatory zoning. Biotite flakes, magnetite, and green hornblende occur as crystals and blebs in the matrix. The orientation of the phenocrysts is random, though flow structure was observed in the field.

Age and correlation.--The andesite porphyry rests upon an extremely irregular surface formed of Precambrian and Mississippian strata intruded by granite. Remnants of the older granite surface appear as topographic highs exposed by removal of the porphyry, and as blocks moved by the flow of andesite porphyry (Pl. XI, A and B). No older extrusives were observed in the vicinity of the porphyry, and it is overlain by andesite. Dating of the andesite porphyry depends partly upon the dating of the overlying andesites, but it is post-granite, probably

post-rhyolite, and pre-andesite in age. Its position above the older post-thrust granite indicates an Eocene age.

### Eocene Andesites

Distribution and description.--A sequence of predominantly andesite extrusives occurs at several localities in the southern half of the West Tintic area.

A broad northwest-trending exposure of predominantly andesitic rocks extends for over six miles across the southern portion of the West Tintic Range and northeast of the West Tintic mining district. The rocks are mostly a medium-grained red-gray to purplish porphyritic andesite. Green and brownish andesites are also present, and locally large areas have been bleached by hydrothermal solutions. Quartz-bearing extrusives were observed in several localities, but were considered of minor importance.

Brown vitrophyre and brownish-purple semi-porphyritic felsite of andesitic composition are exposed. Both vitreous and porphyritic andesites occur in the area mapped as andesite north of the Jerico Road, and these also occur locally with tuffs and vitrophyre in the structural complex mapped in that area.

Andesite exposures east of Maple Peak display considerable shearing and flow lineation that dips steeply eastward. Several exposures of dark-reddish-purple andesite occur about three miles northeast of Maple Peak, in the central portion of the West Tintic Range. The "L" shaped outcrop in secs. 29



A.--Granite boulder in andesite porphyry. The outcrop is about a quarter of a mile east of The Nipples. View is to the northwest.



B.--Closer, more detailed view of granite-andesite porphyry contact. A finer-grained chilled zone in the andesite is present at the contact.

and 32, T. 10 S., R. 4 W., conformably underlies Green River strata and overlies tuff beds and black vitrophyre. The vitrophyre is also present in the exposure immediately south of the "L".

Extrusive rocks occurring in sec. 4, T. 11 S., R. 4 W., and in the small exposure one-fourth mile northeast of the mouth of Little Valley are a dark-red to dark-purple andesite porphyry. A highly altered andesite(?) covers the southern portion of the West Tintic stock in sec. 33, T. 11 S., R. 5 W..

Two-inch andesine phenocrysts were observed in columnar talus blocks from the small exposure in the SE $\frac{1}{4}$  sec. 33, T. 10 S., R. 4 W..

Chicken Rock (Pl. XII, A) is formed of layered andesite (Pl. XII, B) in a possible shear zone. The Chicken Rock andesite layers are contorted and nearly vertical, indicating the possibility of an intrusive origin. Silicification seems responsible for the unusual resistance to weathering displayed by this topographic feature.

Petrography.--An average medium-grained reddish-purple porphyritic andesite from the large exposure in the southern portion of the area contains phenocrysts of anhedral andesine which constitute 40 percent or more of the rock. Biotite, amphibole, and abundant magnetite occur as flakes, crystals, and blebs in a matrix consisting of a very fine crystalline aggregate and partly devitrified glass. Phenocrysts are



A.--Chicken Rock, a prominent topographic feature of the West Tintic mining district, which is composed of a dense, intrusive(?) andesite. A fault contact with tillite on the left extends diagonally across the photo to the upper left. View is to the northwest.



B.--Folded and nearly vertical shear or flow lineation in the Chicken Rock andesite.



crushed, sericitized, and corroded. The abundance of magnetite may be responsible for the dark color of the rock.

Andesite vitrophyre from the exposures west of Indian Springs in the southwestern corner of the mapped area contains small (2 or 3 mm) randomly scattered fragmental phenocrysts of andesine(?) in a slightly devitrified matrix of brownish glass. Phenocrysts constitute less than 10 percent of the section. Small fragments and blebs of magnetite, hematite, and other material are present in the glassy matrix, which has a swirling flow texture.

Dark-purplish andesite from the small outcrop northeast of the mouth of Little Valley contains phenocrysts up to 3 mm in length which range from andesine to labradorite in composition, constitute about 30 percent of thin section, and are suspended in a matrix of partly devitrified glass and a fine crystalline aggregate. Abundant crystals and blebs of magnetite and hematite are present, but no other secondary minerals, except sericite, were observed. Most of the phenocrysts are fractured by viscous flow.

Andesite from the Chicken Rock exposure is light-purple platy and porphyritic. The phenocrysts up to 3 mm in length range from oligoclase to andesine in composition, and constitute about 15 percent of the thin section. Phenocrysts are oriented parallel to the platy cleavage of the rock. The matrix consists of a fine-grained, crystalline aggregate of calcic(?) plagioclase showing a high degree of preferred

orientation. Secondary(?) quartz is present in the matrix, and magnetite and pyroxene fragments are scattered throughout. Both phenocrysts and matrix are slightly sericitized.

Age and correlation.--The andesite apparently overlaps rhyolite in the area north of Chicken Rock. In the central portion of the West Tintic Range interbedded andesites occur below Green River beds which appear to be stratigraphically younger than the rhyolite sequence.

A latite volcanic series overlies the Packard quartz latite in the East Tintic area (Morris, 1957, p. 32). This volcanic series has a thick agglomerate upper member which covers much of the East Tintic Range and extends into the Long Ridge area according to Muessig (1951, p. 127), who (pp. 98-99) dates it as mid-Eocene. The West Tintic andesites lie below a somewhat similar agglomerate or pyroclastic sequence described as a separate unit in this paper. Thus, the andesites are tentatively correlated with the lower portion of the latite volcanic series of the East Tintic area, and may be dated as possible middle Eocene and are considered Green River equivalent.

#### Eocene Andesitic Pyroclastics

Distribution and description.--A thick, predominantly andesitic agglomerate sequence is exposed over a northwest-trending area adjacent to and north of the andesites exposed

in the southern portion of the West Tintic Range. A northwest-trending, northeast-dipping lineation occurs in ridgeline exposures in secs. 20, 21, 28, and 29, T. 11 S., R. 4 W.. This lineation may be due to original deposition on the northeast flank of a volcano, and is an indication that the extrusive rocks in this particular locality are successively younger toward the northeast. Thus, the pyroclastic sequence overlies the andesites.

The pyroclastic materials generally consist of agglomerate with intercalated vitreous flows containing much fragmental material, and some volcanic breccia. The agglomerate consists of a heterogeneous mixture of angular fragments of andesite, with subordinate quartzite, jasperoid and other older rocks, ranging from silt-size to blocks a foot or more in mean diameter. The intercalated flows have a vitreous matrix containing fragmental material usually oriented parallel to the flow lineation, and locally contain black vitrophyre. A possible fissure filling or pipe of volcanic breccia crops out near the bottom of the drainage ravine east of the Precambrian klippe in the NW $\frac{1}{4}$  sec. 28, T. 11 S., R. 4 W., and is made up of angular fragments of igneous and sedimentary rocks in a fine-grained dense hard matrix.

A volcanic plug (Pl. XIII, B) occurs in sec. 4, T. 11 S., R. 4 W., just east of Devils Gate. The rock forming the plug is a gray-green, altered porphyry containing abundant angular fragments of older rocks.

Petrography.--Thin sections were made from several selected specimens of the pyroclastic sequence, and the descriptions of the different pyroclastic types may represent the study of several sections. A typical agglomerate contains angular fragments of porphyritic andesite, partially resorbed quartzite, phyllite(?), limestone or dolomite, and rarely subhedral plagioclase crystals scattered at random in a brownish or greenish, fine-grained crystalline matrix. Biotite and chlorite plates are present and normally are oriented parallel to a faint flow(?) lineation or compacted bogen structure. Zoned crystals are absent.

The volcanic breccia described in the preceding section has sharp, angular fragments of dense jasperoid, fine-grained igneous rock, quartzite and other rock material embedded in a matrix containing scattered biotite and magnetite and material resembling devitrified glass. A faint lineation curves around the fragments, and most of the tabular and elongate fragments have parallel alignment. All the carbonate fragments display alteration rims of fine-grained quartz, and this, along with the presence of quartz veinlets, is considered evidence of secondary silicification.

A weathered specimen of rock from the volcanic plug near Devils Gate is an andesite porphyry with corroded and dis-oriented phenocrysts of andesine averaging 4 mm in length embedded in a dirty-green semidevitrified glassy matrix. Altered fragments of older igneous rock are present. Biotite,



limonite blebs, fragments of a dark pyroxene, and occasional spherulitic structures are scattered throughout the matrix.

The vitreous flow rock occurring northeast of the andesite sequence and having a distant northwest trend and northeast dip, was first thought to be a welded tuff. However, the evidence of biotite plates oriented across the lineation seems to rule out this possibility, and the rock is considered to be a vitreous flow on the flanks of a volcano where pyroclastic material fell on the surface and was picked up as the flow progressed. This explanation accounts for the pyroclastic nature of the fragments and the presence of bogen structures described below.

Small fragments of andesite, jasperoid, quartzite, and other older rocks occur in a matrix of brownish or dark-gray partly devitrified glass. The matrix constitutes about 90 percent of the thin section, and shows a flow lineation that partially curves around the fragments. A few disoriented phenocrysts of plagioclase and potash feldspar were observed, and occasional bogen structures were apparent normal to the flow lineation, but tabular and elongate fragments possess a parallel orientation.

Age and correlation.--The pyroclastics overlie the andesites, and are tentatively correlated with the agglomerate upper member of the Latite volcanic series of the East Tintic Range (Morris, 1957, pp. 32-33) and the Long Ridge area (Muessig,



1951, p. 127). These pyroclastics in the Long Ridge area were positively dated by Muessig (1951, p. 98-99) because they were interbedded with and overlain by a limestone containing a middle Eocene flora.

The pyroclastic sequence of the West Tintic area is therefore tentatively dated as middle Eocene in age.

### Basalt Flows

Distribution and description.--Basaltic flow rocks are the most recent of the extrusive rocks in the area and occur in only three small exposures.

Brown-weathering basalt boulders cap a small hill about 300 yards north of McIntyre Ranch, and another exposure occurs on the north bank of Devils Creek about 1 3/4 miles south of the ranch. The basalt is black with some green serpentine on fresh surface. It apparently overlies andesite rocks in both areas.

Scoriaceous basalt crops out in a low rise between the East Vernon Hills and the west flank of the West Tintic Range. The vesicles are filled with calcite, chalcedony, and green palagonite(?). Fragments of chalcedony weathered from the scoria are often two or three inches long.

Petrography.--Examination of thin sections of the black basalt disclosed phenocrysts of anhedral augite, fractured euhedral labradorite, and rare olivine, averaging less than 3 mm in

length, in a trachytic groundmass of plagioclase (labradorite?) microlites.

Age and correlation.--The basaltic rocks of the West Tintic area either rest upon andesite or have a faulted contact with adjacent bedrock. Pediment gravels cover part of the scoria deposit near the East Vernon Hills, and basalt boulders and cobbles occur in the outmost portion of ridges cut in the pediment gravels in the southern part of the mapped area. Thus, the field relations indicate only that the basalt is post-andesite and pre-pediment gravels.

Basalt rocks in the southern Oquirrh Range are considered by Gilluly (1932, p. 69) to be much later than the principal igneous cycle. Butler (1920, p. 89) believed the latest eruptions in Utah were basaltic. Cohenour (1957, p. 159) states that a basalt flow in the Simpson Range is the youngest extrusive rock in the Sheeprock-Simpson area. Basalt flows in the northeastern part of the East Tintic Range were tentatively correlated with the Salt Lake formation by Bullock (1951, p. 20).

The basaltic rocks of the West Tintic Range are probably Late Tertiary or early Pleistocene in age.

## INTRUSIVE ROCKS

### The West Tintic Monzonite Stock

Location and description.--The West Tintic monzonite stock intrudes the carbonate strata of the Pogonip formation and transects the local structure to the south where it extends for an unknown distance under altered andesites and pediment gravels. The contacts of the intrusion, as mapped (Pl. I), are mostly inferred because of the obscuring debris that covers much of the area. A map prepared by Stringham (1942, Pl. I) shows the intrusion in greater detail than does the present map, and the reader is referred to Stringham's (1942, pp. 267-290) work for a more nearly complete description of the igneous rocks in the West Tintic mining district.

The monzonite is typically a medium-grained granitoid? rock with no evidence of quartz in hand specimen. Grain size and composition may change from one locality to another especially near the contacts.

A monzonite porphyry, related to the stock (Stringham, 1942, p. 275), is exposed east of the Pyramid mine, north of the Allah mine, and west of the Orient workings. The porphyry somewhat resembles the andesite porphyry of the West Tintic Range, but a careful examination shows the groundmass to be phaneritic. The porphyry appears to have been overridden by the main Laramide thrust as presented on the geologic map

(Pl. I). However, the contacts with the Precambrian rock are covered, and the nature of the contact is not positively known.

Petrography.--Thin sections from selected specimens of the monzonite stock and the associated(?) monzonite porphyry were given a cursory examination to verify the previous work of Stringham (1942, pp. 274-275), who described these rocks as follows:

"The typical monzonite has a uniform medium-grained granitoid texture. White plagioclase, light-pink orthoclase, biotite, and small crystals of hornblende are discernible in hand specimen. In all of several specimens studied microscopically it was found that orthoclase predominates slightly over plagioclase ( $An_{32}$ ), quartz varies from 8 to 17 percent of the whole rock, and hornblende remains constant at around 5 to 6 percent. Medium-sized plates of biotite constitute 10 to 12 percent. Sphene, augite, magnetite, and apatite are the accessories. Chlorite, magnetite, sericite, and epidote, present in all specimens in minor amounts, indicate that alteration has been slight. The typical texture is seriate with the largest crystals 3 to 4 mm. in dimension. Most of these are prominently zoned plagioclase with twinning on the Carlsbad, Albite, Manebach, and Pericline laws. Determination of the compositions of the zones showed that the anorthite content decreases toward the rim of the crystal. Some cores contained as high as 67 percent anorthite, and rims as low as 10 percent. A few crystals of orthoclase are also present. The boundaries of these larger crystals tend toward idiomorphism. Medium-sized hypidiomorphic crystals of perthitic orthoclase, plagioclase, and quartz constitute the bulk of the rock. The crystals of hornblende may show either good crystal outlines or ragged edges. Occasional remnants of augite within hornblende crystals suggest that it has a uraltic origin.

"Under the microscope the larger phenocrysts (of the monzonite porphyry) are found to be well-twinned, idiomorphic plagioclase ( $An_{30}$ ) with little or no zoning, while many smaller crystals have ragged edges. Large crystals of dark-brown biotite have been altered to chlorite around their edges, and smaller ones are wholly chloritized. The groundmass is composed of interlocking



crystals of orthoclase, chlorite after biotite, and some quartz. Various stages in alteration are found in specimens taken from different places. Sericite, chlorite, and carbonate are always present. Zoisite and epidote appear only occasionally. An exposure in the excavation for a powder house near the Old Scotia Mine shows the porphyry to have been fractured and sericite and carbonate developed to such an extent that only remnants of the green porphyry are left. Hydrothermal action explains most of these alterations."

The composition of the monzonite stock is more basic near the metamorphosed contact with carbonate rocks. This was probably caused by assimilation of calcium which produced the diorite facies present near the Iron King mine and south of the Desert Tungsten workings.

Contact relations.--Contact metamorphism is present throughout much of the West Tintic mining district, but becomes less conspicuous with distance from the monzonite stock. Tactites and skarns characterized by garnet, magnetite, scheelite, and tremolite or wollastonite are present at the Iron King and Desert Tungsten mines. Most of the carbonate strata in the district have been recrystallized, commonly bleached, and locally contain scattered tremolite aggregates. The Kanosh shale has been altered to a slaty hornfels, and locally the Precambrian tillite has been recrystallized to a fine-grained schist. Contact phenomena in the district are discussed by Stringham (1942, pp. 276-279), and the reader is referred to this work for more detailed information.

Age and correlation.--The West Tintic monzonite was considered by Loughlin (Butler, et al., 1920, p. 439), Stringham (1942,



pp. 285-286), and Cohenour (1957, p. 154) to be post-Laramide thrust phase in age. However, no positive evidence that the monzonite had anywhere intruded the upper thrust plate was found during the present investigation. Granite has intruded both the monzonite and country rock of the district, and is considered to have caused thermal metamorphism of the allochthonous rocks in the area. The granite unconformably underlies probable middle Eocene andesite in the West Tintic Range. Therefore, the monzonite is probably pre-middle Eocene in age.

A correlation with monzonite rocks of other areas is not practical, but Morris (1957, p. 30) has dated quartz monzonite intrusives of the East Tintic Range as middle Eocene on the basis of "zircon" analyses and relations to the latite volcanic series.

### The Granite Intrusives

Distribution and description.--Granite rocks intrude the monzonite, the Paleozoic strata, and the Precambrian rocks of the Laramide allochthon in the West Tintic mining district. The granite surface in the southern portion of the West Tintic Range is an old erosion surface exposed by the removal of the overlying andesite porphyry.

The largest intrusion of granite in the West Tintic mining district (Pl. XIII, A) has intruded the allochthonous



A.--Weathered granite exposed northwest of the Scotia Mine, in the West Tintic mining district. View is to the west. Note hammer for scale.



B.--Volcanic plug near Devil's Gate. View is to the north. The plug is about 25 feet in height.

precambrian rocks northwest of the Scotia mine. The granite is coarse-grained near the center of the exposure and is a finer-grained porphyry near the contact with altered sedimentary rocks. A medium-grained granite porphyry occurs at the Oro Plata mine, and a fine-grained granite (almost an aplite) is intrusive into Pogonip strata and the monzonite stock west of the Iron King mine.

A hill, a half mile southeast of Chicken Rock, is composed of a fine- to medium-grained granite or intrusive rhyolite porphyry, with abundant phenocrysts of quartz and pink orthoclase in a finer-grained groundmass of mostly sericitized material. Loughlin (Butler, et al., 1920, p. 436) concluded that an eruption vent was present here, and the vent rock ranged from a "fine-grained porphyry to rhyolite porphyry."

Petrography.--All the granites in the West Tintic mining district, except the exposure southeast of Chicken Rock, have been adequately described by Stringham (1942, pp. 275-276). The granite (or intrusive rhyolite?) in the Chicken Rock vicinity has anhedral phenocrysts and sharp fragments of quartz up to 6 mm in size which constitute about 30 percent of the thin section. Fragmental phenocrysts are embedded in a gray-green sericitized groundmass of smaller crystal fragments of sodic plagioclase and potash feldspar in an even finer-grained crystalline aggregate. Chlorite and magnetite are present. The rock has a cataclastic texture.

Coarse-grained granite from the old erosion surface in the southern part of the West Tintic Range consists of coarse (to 12 mm in length) grains of quartz, orthoclase, and subordinate sodic plagioclase, with minor magnetite, sericite, and limonite.

Contact relations.--The only granite contact relations observed were in the intrusion northwest of the Scotia mine where the coarse-grained center facies changes to a fine-grained porphyry facies near the contact.

Age and correlation.--All granite exposed in the mapped area is considered to be genetically the same, and may be related to the granite stock west of the mapped area in the Sheeprock Range. Cohenour (1957, p. 157) has accepted a Miocene dating of the Sheeprock granite, as determined by the U. S. Geological Survey by use of the "Larsen" or "zircon" dating procedure. However, if the Sheeprock granite can be considered as equivalent to the granites of the West Tintic area because of its proximity, then all of the granite is much older than Miocene. Fractionation of the granite magma could have produced the rhyolite sequence which is considered to be the oldest Tertiary extrusive rock in the area, is below proven Green River strata, and is pre-middle Eocene in age. The old dissected granite surface in the West Tintic Range lies below the andesite porphyry which is, in turn, overlain by andesites and pyroclastics tentatively correlated with the middle-Eocene volcanic

series of the East Tintic and Long Ridge areas. The granite is known to intrude the Laramide allochthon and is, therefore, dated as post-Laramide thrust phase (late Paleocene) and pre-middle Eocene.

## ALTERED ROCKS

### GENERAL STATEMENT

Extensive alteration of sedimentary and extrusive rocks has occurred in the West Tintic Range. Most of the alteration is hydrothermal, though some is attributed to circulating groundwaters of non-thermal character. Alteration resulting from proximity to intrusive contacts occurs in the West Tintic mining district, and was briefly discussed in connection with intrusive rocks (see p. 128).

The types of alteration other than contact metamorphism in the West Tintic Range are: (1) propylitization, (2) dolomitization, and (3) silicification. Of the three types, silicification has the greater significance. In nearly all places alteration occurs in the proximity of the conduit (fault or fissure) that carried the hypogene fluids upward.



## PROPYLITIZED ROCKS

Propylitization was defined by Grout (1932, p. 416) as a hydrothermal process in which potash, sulfur, and water are added to the existing rock, while soda and lime are removed. Howell (1957, p. 232) defines propylitization as:

"The introduction of, or replacement by, an assemblage of minerals including carbonates, epidote, secondary quartz, and chlorites. Other minerals, such as pyrite, zeolites, alkali feldspars, or sericite may also be formed, and the process is most characteristic in the hydrothermally altered, fine-grained, intermediate rocks such as andesites."

Howell further defines the rock name "propylite" as:

"An altered greenstone-like andesitic rock consisting of such minerals as calcite, chlorite, epidote, serpentine, quartz, pyrite, and iron ore and resulting from hydrothermal alteration."

Stringham (1957, personal communication) stated that the mineral celadonite may also be produced by propylitization.

Propylite occurs at a prospect in fissured rhyolite 200 yards north of Utah Highway 36, west of the railroad and near the northern boundary of the mapped area. A larger propylitized zone occurs in tuffaceous rocks immediately north of the basalt outcrop between the East Vernon Hills and the West Tintic Range. Two prospect shafts in the SE $\frac{1}{4}$  sec. 6, T. 11 S., R. 4 W. are driven in propylitized rhyolite, and extensive propylitization is present in the andesites overlying the southern portion of the West Tintic monzonite stock. Celadonite occurring in the unnamed greenstone probably formed originally

in propylitized andesite (see p. 96). Abundant small veins, seams, and fissures are filled with propylite in the extensive exposure of the andesites in the southern part of the West Tintic Range.

#### DOLOMITIZED ROCKS

Secondary dolomitization is common in the West Tintic area, as it is in the East Tintic mining district (Lovering, 1949, pp. 16, 21-23). Most of the West Tintic carbonate strata ranging from Cambrian through Mississippian (Madison) locally contain secondary dolomites which extend outward from faults or fissures for considerable distances into adjacent limestones.

Light-gray dolomites transect the bedding of the Middle Cambrian limestone-shale sequence along the ridge south of Sabe Peak. Much of the Fish Haven-Laketown dolomite involved in Laramide thrusting was brecciated and later healed by secondary dolomite. A portion of the extreme southwestern exposures of the Madison limestone have been extensively dolomitized, and display a characteristic "zebra" striping of light and dark dolomite.

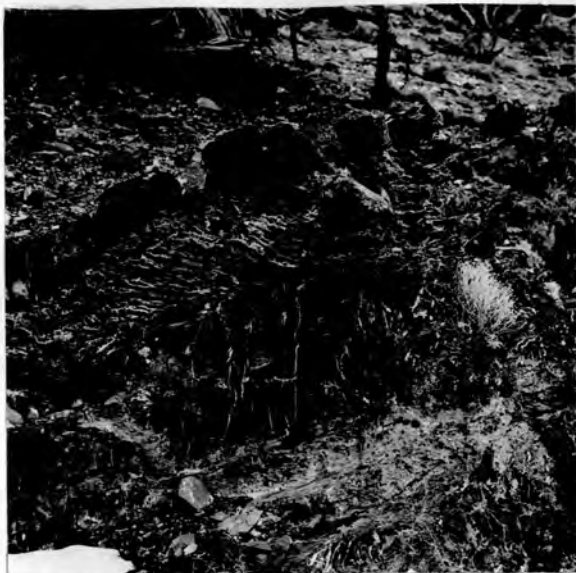
## SILICIFIED ROCKS

### Distribution of Jasperoid Exposures

Jasperoid is a term which designates any rock composed of secondary silica of either hypogene or supergene origin (Howd, 1957, p. 131). Considered in this sense, the silicified carbonate, sandstone, and extrusives of the West Tintic area are jasperoids.

Jasperoids are usually limited to faults, fissures, and permeable strata or crushed zones in their vicinity. Exposures of jasperoid are indicated on the geologic map by stippling, and reference is made to the map for location and type of original rock (see Pl. I).

Silicified sandstone and limestone beds of the Deseret-Humbug unit extend southward from the trace of the thrust fault in sec. 2, T. 9 S., R. 5 W.. Silicifying solutions apparently moved up along the fault zone and spread outward into permeable sandstone and fractured cherty limestone. Large massive exposures of vuggy red jasperoid cap high hills north of Bennion Ranch in sec. 15, T. 9 S., R. 5 W., and cut across Great Blue limestone strata in the same area (Pl. XIV, B). In secs. 22 and 23, of the same township jasperoids occur in the Deseret-Humbug, Madison, Sevy-Simonson, and Fish Haven units. Jasperoid in the Madison of this area occurs as reconstituted jasperoid breccia which is considered evidence of two stages of silicification.



A.--An early arrested stage of silicification in Great Blue limestone strata near the Humbug contact in the SW $\frac{1}{4}$  sec. 16, T. 9 S., R. 5 W.. The silicified bed is about 18 inches thick.



B.--Selective jasperoidization (dark areas) of Great Blue limestone. The location is near that of A (above).

Jasperoid crops out south of the road in the questionable Great Blue limestone exposure between Benmore and the Bennion Ranch. A thin surface covering of jasperoid on Fish Haven dolomite occurs north of the Swan Peak outcrop in the SW $\frac{1}{4}$  sec. 26, T. 9 S., R. 5 W., and is considered evidence of a former thrust sole. Some 200 yards south in sec. 35, jasperoid crops out in the thrust sole where Precambrian Mutual quartzite rests on inferred Paleozoic carbonates.

The longest exposure of jasperoid in the area crops out along the western boundary of secs. 8, 17, and 20, T. 10 S., R. 4 W., southeast of Sabe Peak. This exposure can be traced for almost two miles and is considered localized by a major Basin and Range fault. The area east of the "Iron" Mine in secs. 13 and 14, T. 10 S., R. 5 W. and secs. 18 and 19, T. 10 S., R. 4 W. is characterized by outcrops of jasperoid (Pl. XV, B) including a hill of silicified rhyolite. Immediately south of the "Iron" Mine jasperoids mark a north-trending fault in the Deseret-Humbug unit. "J" Hill is capped by a massive deposit of jasperoid which marks the eastern branch of the Vernon Creek fault (Pl. XV, A).

Jasperoid outcrops associated with faults occur on the east slope of McIntyre Mountain, in the Sevy-Simonson dolomite east of McIntyre Mountain in secs. 6 and 7, T. 11 S., R. 4 W., and at Devils Gate. Exposures of varicolored jasperoid in the southwest corner of the mapped area are associated in a structural complex where Paleozoic limestones, Precambrian





A.--"J" Hill, showing the capping jasperoid outcrop. View is south along Vernon Valley toward the hill.



B.--Jasperoid east of the "Iron" Mine. Note folding in the remnant thin bedding.

quartzites, and Tertiary extrusives occur in a heterogeneous combination impossible to map at the 1/20,000 scale of Plate I.

### Description

Fresh surfaces on hand specimens of jasperoid range from black through gray to red, brown, yellow, green, and white. Weathered surfaces are predominantly red and brown, though some are nearly white. Jasperoids may resemble chert or quartzite. Medium to coarse-grained types are normally silicified sandstone. Some jasperoid may easily be mistaken for quartzite, but usually a sharp blow with a field hammer will more readily shatter the brittle jasperoid. Also, the weathered forms of jasperoid are normally more rounded than quartzite, and a hand lens examination of fresh specimens shows a finer grain than quartzite. Primary features of the original rock are locally preserved in the jasperoids.

Jasperoid outcrops are more resistant to weathering than limestone or shale and tend to form ridges, but are not as resistant to semi-arid weathering processes as is massive dolomite or quartzite. Many incompletely silicified carbonates contain vugs and veins with quartz crystal and goethite fillings (Pl. XIV, A). Most of the red to brown-weathering outcrops contain prospect pits.

## Petrography

Petrographic studies of thin sections from selected jasperoid specimens indicate the presence of at least three types of jasperoid in the West Tintic area: (1) jasperoid having a very fine-grained to cryptocrystalline quartz ground-mass, abundant micro-fissures of vein quartz, and scattered, irregular quartz grains thought to represent original nuclei; (2) cherty jasperoid containing rhythmic banding and colloform textures observable in plane light; and (3) jasperoid breccia with fragments of older jasperoid in an opaline, colloform textured matrix.

Hematite and limonite(?) blebs were observed in thin sections of the red to brown-weathering jasperoid. The matrix in all colored jasperoid is turbid in plane light and minute disseminated carbon(?) particles, iron oxide, and sphalerite(?) are believed to cause this turbidity. Barite, tourmaline, and other minerals noted by Lindgren (1919, pp. 151-158) and Gilluly (1932, pp. 97-101) were not observed in thin section studies of the West Tintic jasperoid.

## Origin of the West Tintic Jasperoids

The origin of jasperoids has been discussed by Lindgren (1919, p. 156), who theorized that the jasperoid in the East Tintic mining district was formed by a replacement of limestone or dolomite by colloidal silica, which immediately afterwards

was transformed into chalcedony or granular quartz with a resulting contraction of volume. Gilluly (1932, pp. 100-101) essentially agrees with Lindgren, but presents a more detailed discussion, including a consideration of whether or not colloidal silica could be deposited at temperatures high enough to permit the formation of tourmaline. Both Lindgren and Gilluly are convinced that jasperoids result from hydrothermal action.

It is probable that jasperoid associated with fissures, thrust soles, high angle faults, and breccia zones is hydrothermal in origin, but the goethite and crystalline quartz vug and fissure fillings plus limonite blebs in the jasperoid are likely the result of later supergene water circulation. Justin Kreek (1957, personal communication) observed stalactite-like projections of silica into underlying pumicite or tuff beds about three miles north of the mapped area. This material is probably silicified tuff, and appears to be evidence of supergene silicification. Thus, jasperoids of both hypogene and supergene origin are present in the area.

#### Age of Silicification

Hypogene jasperoids of the West Tintic area were formed in two separate periods. The earliest period is post-Laramide thrust phase and pre-;yroclastic sequence, and probably coincides with the siliceous granite intrusions. Evidence to support the age of the older jasperoid, is the

presence of jasperoid in or below the sole of some of the thrust faults, and its presence as included fragments in agglomerates and volcanic breccias. A later period is related to the development of north-trending high-angle Basin and Range faulting, and is subsequent to the age of silicified portions of the Salt Lake group.



## STRUCTURE

### MAJOR STRUCTURAL FEATURES

#### General Statement

In general, the West Tintic Range consists of a complex westward overturned anticline of Paleozoic strata (Pl. II, secs. AA' and CC'). The anticlinal core of the range is believed to be partially covered by allochthonous Precambrian to Pennsylvanian strata of the Sheeprock thrust system, the Precambrian rocks of which constitute the eastern and southern flanks of the Sheeprock Range. Autochthonous Paleozoic strata occur in the West Tintic mining district (Pl. II, sec. DD'), but the Paleozoic strata in the vicinity of McIntyre Mountain are probably allochthonous (Pl. II, sec. CC').

#### Structural Complex

Certain areas were mapped as a structural complex (see geologic map, Pl. I), because the sedimentary, igneous, and altered rocks are so complexly folded and faulted that it is impractical to map them except at a very large scale.



A.--The Maple Peak anticline. View is to the south along the fold axis. The structure is overturned to the west (right), with resistant Chiulos quartzites forming the flanking ridges. Maple Peak is in the right background.



B.--Small anticlinal fold in the Chiulos member east of the Maple Peak anticline. View is to the northeast, photo was taken from a position southeast of the east (left) ridge in A (above).

The largest exposure of the structural complex occurs just southwest of McIntyre Mountain where the rocks consist of faulted Paleozoic carbonates, intruded(?) and covered by altered rhyolite and agglomerate. Another exposure of the structural complex occurs just west of the Jerico Road near the southwest corner of the map. In this area the surface of a major thrust sole is exposed as silicified Paleozoic limestone. Remnants of Precambrian quartzite breccia rest on jasperoid and limestone, and are largely concealed by later extrusives.

### Folds

West Tintic anticline.--Paleozoic strata of the West Tintic Range form a westward overturned homocline in the northern part of the range and a complex anticline, also overturned westward immediately north of Maple Peak (see Pl. II, secs. AA' and CC', and Pl. XVI). The Maple Peak anticlinal structure is thought to extend southward under thrust remnants and extrusives to the southern terminus of the range where complexly folded Mississippian strata are exposed.

Monocline north of Little Valley.--Precambrian Mutual(?) strata have an easterly trend and dip steeply northward to the north of Little Valley, at the southern terminus of the Vernon embayment, and east of Vernon Creek in the West Tintic Range. The monocline is probably an eastward extension of the Sheeprock monocline described by Cohenour (1957, p. 172).

Brown's Ridge homocline.--The Brown's Ridge homocline is a prominent feature of the West Tintic mining district (Pl. I). It consists of north-trending, nearly vertical Paleozoic strata overturned eastward (Pl. II, sec. DD'). The structure is covered on the south by pediment gravels and on the north by the Precambrian allochthon.

McIntyre syncline.--The McIntyre syncline is formed of Mississippian and Devonian strata on the north slope of McIntyre Mountain (Pl. II, sec. CC'). The structure plunges to the northwest where it is covered by rhyolite, Mutual(?) sole breccia (Pl. XVII, B), and the alluvium of McIntyre Valley.

Recumbent folds.--A major north-trending recumbent limb of an anticline in the vicinity of Pole Canyon was described by Cohenour (1957, p. 162). The fold described is immediately west of the present mapped area and lies north of the Tooele-Juab County boundary. Cohenour suggested that the overturned east limb was thrust eastward. Precambrian strata in the area east of this structure are overturned nearly to horizontality. Cambrian Tintic quartzite and the limestone-shale sequence exposed in the fault complex southwest of McIntyre Valley were observed to be in an inverted relation (Pl. I, and Pl. II, sec. CC'). Evidence deduced from the stratigraphic sequence and cross-bedding indicate that overturned Precambrian strata extend southeastward to the vicinity of Chicken Rock in the West Tintic mining district.

More recent folds and flexures.--Green River-Salt Lake strata exposed in the central portion of the West Tintic Range dip eastward as much as 50 degrees. A similar, but less steep, attitude was observed in Salt Lake beds along the eastern flank of the West Tintic Range. Variations in the attitude of Salt Lake strata were observed in road and railroad cuts in the northeastern part of the mapped area. Recurved or semi-annular drainage patterns are present in the pediment gravels covering Salt Lake strata in secs. 17 and 20, T. 9 S., R. 4 W., and these drainage patterns are considered to be superposed on previous structurally controlled drainage systems cut in the Salt Lake group. A plunging anticlinal or synclinal structure is suggested as being responsible for the recurved drainage pattern.

#### Faults

Sheeprock thrust system.--The allochthonous nature of the Precambrian rocks north and east of the West Tintic mining district was first recognized by Loughlin (Butler, et al., 1920, p. 432). Eardley (1939, pp. 1284-1285, and Pl. I) named the Sheeprock thrust, which he considered to be the major structural element of the Sheeprock uplift, and noted considerable horizontal displacement. Stringham (1942) and Gardner (1954) further defined the thrust in the West Tintic mining district and adjacent portions of the West Tintic Range, and



Cohenour (1957, pp. 164-166) discussed the occurrence of the thrust in the Sheeprock Range.

The Sheeprock allochthon is here interpreted as having moved eastward along several thrust planes. Thrusting in the area of investigation is characterized by a sequence of imbrications belonging to the Sheeprock thrust sequence. Movement along the imbrications differed in magnitude and in time in which displacement occurred, but all movements are essentially eastward.

The imbricate nature of the thrusting is clearly evident north of Little Valley where a segment of the Mutual(?) quartzite was thrust a short distance to the southeast over the allochthonous upper phyllitic shales of the Sheeprock series. Eastward movement along an imbrication below the main Precambrian allochthon has placed the Tintic quartzite over younger Cambrian and Ordovician(?) carbonates southwest and south of Sabe Peak.

In the Maple Peak area, questionable Fish Haven-Laketown dolomite have been thrust over Mutual(?) quartzite. This relation is reversed in the southern part of the West Tintic Range where Dutch Peak tillite is thrust over questionable Fish Haven-Laketown strata which, in turn, were observed to lie in thrust contact upon the shales of the Chiulos member of the Great Blue limestone. Other imbricate structures are present in the vicinity of McIntyre Mountain (Pl. II, sec. CC') and in the West Tintic mining district where questionable

Tintic quartzite has been thrust over the Dutch Peak tillite (Pl. II, sec. DD').

Strata as recent as the Great Blue formation are known to have been involved in thrusting near the northern portion of the mapped area. It is possible that the Oquirrh formation is also involved in the thrusting (see Pl. II, sec. AA'), as it is just north of the mapped area. Thrust remnants of quartzite breccia resting on jasperoid and Paleozoic(?) limestone in the structural complex immediately north of Jerico Road indicate that thrusting at one time extended across this part of the area.

The complex relations shown on the geologic map (Pl. I) were affected, it is believed, by a series of thrusts which overrode the Paleozoic core of the West Tintic Range and, perhaps, moved blocks or segments of the underlying strata short distances eastward. Later thrusts probably cut across the earlier sheets to add to the complexity of the pattern. Several klippen exposed by the erosion of extrusives in the southeastern part of the West Tintic Range indicate that the allochthon extended over much, if not all, of the present area. The predominant Precambrian composition of the Pleistocene pediment gravels east of the West Tintic Range supports this contention. The total dislocation of the Sheeprock thrust system is not known, but the stratigraphic displacements suggest a minimum movement eastward of about 12 miles. The dislocation was probably much more than this figure, however,

for it is probable that all the Precambrian rocks in the area investigated are allochthonous.

It cannot be shown that the Sheeprock thrust system is a part of any other thrust, such as the Canyon Range Thrust (Christiansen, 1952, p. 730) because of the wide stretches of alluvium and Tertiary deposits which separate the thrust remnants. Many localized thrust fault zones are known to occur throughout the Basin and Range province, and the Sheeprock thrust system may be contemporaneous with some of these. For example, Misch (1957, pp. 1854-1855) describes several flat thrusts in northeastern Nevada which have possible dislocations of 40 to 70 miles. Hazzard (1957, p. 1829) discusses decollement-type overthrusting in Idaho, northwestern Utah, and northeastern Nevada, but gives no figures relative to distance of displacement.

Tear faults.--The fault which parallels Indian Hollow, and extends from the western edge of the mapped area to the tension fault zone southwest of McIntyre Valley is interpreted as a tear. It separates overturned strata of the Mutual(?) formation on the north from overturned(?) strata of the Sheeprock series on the south. Differential forces seem to have produced a greater eastward movement of the south block than the north, and tensional stresses are believed responsible for the fault pattern a mile west of McIntyre syncline.

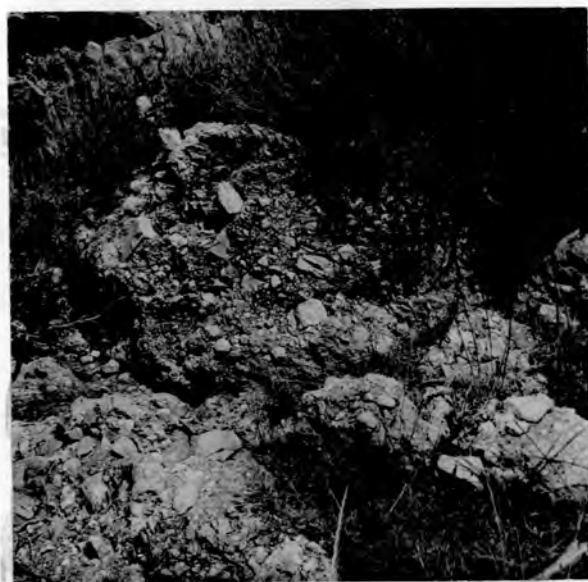
A poorly defined northeast-trending tear fault extends from the northern part of Horse Valley toward Chokecherry Springs in Little Valley. A tear fault in the western part of Little Valley trends northeasterly from the western boundary of the map past the Blackhawk mine. The Dutch Peak tillite-upper phyllitic shale contact north of Little Valley is along a major tear fault, which extends eastward across Vernon Creek to the eastern limit of the thrust plate. Southeast-trending tear faults have been mapped as displacing Paleozoic strata northeast of Bennion Ranch, and a major east-trending tear fault is believed present in the complexly faulted area where Utah Highway 36 crosses the West Tintic Range at the northern edge of the mapped area.

Dislocation along the tear faults may have occurred in two widely separate periods of time, the first movement being strike-slip contemporaneous with the major thrust faults and a later dip-slip displacement, as evidenced by fault-line scarps in the vicinity of the tear faults.

Vernon Creek fault.--The major high angle fault in the West Tintic area is the Vernon Creek fault, so named by Gardner (1954, p. 35) because it parallels Vernon Creek. The block east of the Vernon Creek fault is interpreted as the upthrown block, and the ridge east of McIntyre Valley as a fault scarp (see Pl. II, sec. CC'). The amount of dislocation is not known, but movement along the fault may account for several hundred



A.--Mutual(?) quartzite breccia, just east of the Vernon Creek Road in sec. 2, T. 10 S., R. 5 W.. Note hat for scale. View is to the southeast.



B.--Mutual(?) quartzite breccia, south of the road in McIntyre Valley. Outcrop is near the center of sec. 1, T. 11 S., R. 5 W.. The breccia is thought to be just above the sole of a major thrust. Larger fragments are about six inches in diameter.



feet of the present elevation of the West Tintic Range. The Vernon Creek fault is over 15 miles in length, and has been traced for most of this distance on aerial photographs. Just north of "J" Hill the fault splits into two branches, one of which continues along the eastern edge of the Vernon Creek Valley and southward across the Vernon-Cherry Creek divide, while the other extends through the silicified fault zone of "J" Hill and dies out to the southeast. The area between the two branches is interpreted as a horst.

Other high-angle faults.--The north-trending jasperoid zone southeast of Sabe Peak is considered evidence of a nearly vertical fault of unknown displacement. The jasperoid zone has been traced for  $1\frac{1}{2}$  miles, and probably extends for a much greater distance along the eastern flank of the West Tintic Range. The west block is interpreted as upthrown.

A north-trending fault with western block upthrown is inferred in Salt Lake strata immediately east of the east-facing Terrace in secs. 9 and 16, T. 9 S., R. 4 W.. Faults in the Great Blue limestone southwest of McIntyre Ranch apparently cut the adjoining Salt Lake strata. Several high-angle faults displace Mississippian strata in the southwest part of the mapped area to form horst and graben structures (Pl. II, sec. EE'), but it is difficult to determine if they displace the Eocene extrusives in that area.

## Structural Relations in the Area

The relations of some of the major structures are somewhat in doubt, because of the absence of criteria needed to determine their sequence. The westward overturned anticlinal core of the West Tintic Range is not consistent with the eastward movement of the Sheeprock allochthon which apparently extended across the West Tintic Range. This inconsistency may be interpreted to mean that a distinct phase of folding preceded the thrusting. Remnants of the allochthon rest for the most part upon strata of the Mississippian Great Blue limestone and its incompetent Chiulos shale member. The absence of uppermost Paleozoic and of Mesozoic strata may be interpreted as indicating a pre-thrust episode of uplift and erosion.

The steeply inclined beds of Brown's Ridge homocline appear to be truncated by the major thrust plane in the West Tintic area (Pl. II, sec. DD'), though this cannot be definitely substantiated because of the difficulty in establishing fold axes in the allochthon.

The east-trending, steeply north-dipping Mutual(?) strata of the monocline north of Little Valley are related to Mutual(?) strata of similar attitude in the large Sheeprock monocline situated west of the mapped area. The occurrence of two fensters about a mile north of the mouth of Little Valley verify the allochthonous nature of this structure, and it

seems reasonable that the Mutual(?) strata were thrust eastward after a period of folding.

Faults and folds such as the Vernon Creek fault and the flexures in the Green River-Salt Lake strata are definitely post-thrusting. The Vernon Creek fault has displaced allochthonous strata and has affected the present topographic expression within the area.

### REGIONAL RELATIONS

#### The Cedar Hills Orogeny

Evidence for the rising of Early Cretaceous fold and thrust mountains in the Canyon Range, about 30 miles south of the West Tintic Range, is cited by Christiansen (1952, pp. 732-735). The Canyon Range thrust is deeply eroded and buried under several thousand feet of Indianola conglomerate of Cretaceous (Colorado) age (Christiansen, 1952, Pl. 3). Extensive effects of a Cretaceous disturbance are present in the Cedar Hills where thick coarse Indianola conglomerates attests the presence of an orogeny immediately to the west (Schoff, 1937). Eardley (1951, p. 273) named this disturbance the Cedar Hills orogeny. Other areas affected by such an orogeny are: the East Tintic Range, where Morris (1957, p. 54) cites the presence of regional uplift in latest Jurassic or Early Cretaceous; and in the Gunnison Plateau, where Speiker

(1949, p. 78-79) points out that the molasse-type conglomerates of the Indianola group can hardly mean anything other than orogeny to the west.

Based on the evidence of orogeny in nearby areas, it is postulated that the Cedar Hills orogeny affected the West Tintic area and resulted in uplift and folding. Thus, the West Tintic anticline, the monocline north of Little Valley, and the Brown's Ridge homocline are tentatively assigned to the Cedar Hills orogeny.

### The Laramide Orogeny

The region to the north and east of the West Tintic area was intensely affected by the Laramide orogeny of latest Cretaceous (Montana) and earliest Tertiary age. The Laramide orogeny is discussed by Eardley (1951, pp. 325-332), who divided the orogeny into several phases on the basis of structural relations and the presence of thick conglomerate groups (orogenic deposits) in the Wasatch area.

Thrusting in the West Tintic area is believed to have taken place during one of the Laramide compressional phases. Uplift, erosion, emplacement of granite and deposition of extrusive rocks probably took place during the late phase.

## The Basin and Range Orogeny

The correlation of Basin and Range structural features with those elsewhere in the region is accomplished by their relation to Tertiary deposits and topographic expression. The Vernon Creek fault, the faults in the southeastern part of the mapped area, the north-trending fault southeast of Sabe Peak, and other high-angle faults in the area are assigned to the Basin and Range orogeny. The outward dipping attitude of the Green River-Salt Lake strata and flexures and folds in these strata is believed due to uplift of the West Tintic Range in Late Tertiary time.

## SEQUENCE OF OROGENIC EVENTS

### Early Cretaceous Cedar Hills Orogeny

In late Jurassic(?) and Early Cretaceous the Cedar Hills orogeny influenced a broad belt from southern Nevada northward through western Utah and eastern Nevada to southern Idaho (Christiansen, 1952, p. 733). The absence of Mesozoic and Permian strata in the West Tintic area may be due to Early Cretaceous uplift and erosion throughout the remainder of Cretaceous time. The formation, in part, of the West Tintic Range anticline probably took place during the Early Cretaceous orogeny, as did the folding of the Brown's Ridge homocline and the Sheeprock monocline.



## Laramide Orogeny

The compressional phase of the Laramide orogeny took place in latest Cretaceous (Montana) and may have extended into earliest Tertiary (early Paleocene). The West Tintic monzonite stock seems to have been intruded during or prior to this time, but evidence to support this postulate is lacking.

The compressional phase was characterized by eastward directed forces that produced recumbent folds and thrust segments of the crust at least 12 miles eastward over previously folded Paleozoic strata. The McIntyre syncline, and the east-trending tear-faults were probably formed during this phase, and further(?) folding of the anticlinal structure of the West Tintic Range occurred.

## Late Laramide Orogeny

The compressional phase of the Laramide orogeny ended in early Paleocene, and the late Laramide or post-thrust phase was characterized by igneous activity which continued to middle(?) Eocene. Granite intruded the allochthon and underlying rocks in the southern part of the area. Contemporaneous rhyolite flows were extruded, and were followed by andesite flows and the deposition of pyroclastics. Silicification occurred along the thrust planes and other conduits. The relaxing of compressional forces probably initiated vertical movements along the older tear faults.

## Sequence of Tertiary Deposition

Limestone conglomerates around the perimeter of the Maple Peak anticline are tentatively correlated with the Wasatch group or Flagstaff formation of Paleocene age. The conglomerate probably represents rapid deposition from nearby highlands formed during the Laramide compressional phase. Following an erosion interval which removed most of the conglomerate, rhyolite was extruded over the area. A post-rhyolite erosion period occurred before the Green River and intercalated andesite flows of middle Eocene age were deposited. The Green River-Salt Lake contact was not observed, but lacustrine deposition of Salt Lake strata continued in settling intermontane basins from Oligocene to late(?) Pliocene. Limestone, clay, and silt deposition in the lake basins were augmented by ash falls from an undetermined source. In late(?) Pliocene time, block faulting and differential uplift of the West Tintic-Sheeprock Ranges took place. Flexures formed in the Salt Lake formation at this time, and movement along the Vernon Creek fault began to separate the West Tintic Range from the Sheeprock Range. The intermontane lakes were drained, conglomerates were deposited along the lake basin boundaries, and the process of pedimentation was initiated.

### Quaternary Events

In Quaternary time pedimentation along the flanks of the West Tintic Range was interrupted. The pediment surface truncated flanking conglomerate bajadas before slight renewed uplift, changes in climate, or lowering of base level initiated the present erosion cycle which is removing the pediment gravels from the range and dissecting the pediment surface. This latest readjustment is considered to have taken place just prior to Bonneville time, but no relation to Bonneville sediments can be made as none are present in the area.

## ECONOMIC GEOLOGY

### GENERAL STATEMENT

There is no record of production of metallic minerals from the West Tintic Range, though the adjacent Sheeprock Range has had sporadic and limited production from a number of mines in several mining districts. Two of these districts, the West Tintic, and the Blue Bells are largely within the present area of investigation.

In the West Tintic Range abandoned prospects are found on almost every gossan, rust-stained jasperoid exposure, and outcrop of greenish propylitized extrusive rock. Some silver-bearing jasperoid float is present in gravels thought to have originated in the vicinity of Maple Peak, but the source has not been located (Jim Quigley, 1957, personal communication). Some commercial calcite produced from quarries along Utah Highway 36 about three miles east of Vernon represents the only known economic production of minerals from the West Tintic Range.

The West Tintic and Blue Bells mining districts on the southern and eastern flanks of the Sheeprock Range have had a long history of production. No large bodies were developed

in these districts, and it is likely that not more than two mines produced ore valued in excess of the cost of development.

No attempt was made to enter the old, dangerous, and relatively inaccessible mine workings in the area.

## THE WEST TINTIC MINING DISTRICT

### Location

The West Tintic mining district is principally in the mineralized Paleozoic rocks exposed below the Laramide allochthon near the southern terminus of the Sheeprock Range, though its northern boundary is the Tooele-Juab County line. The district is easily accessible by means of graveled roads leading to the Scotia and Desert Tungsten mines.

### History and Production

Prospectors were attracted to the West Tintic area by scattered surface "blooms" shortly after ore was discovered in the East Tintic district in 1869. The West Tintic mining district was organized in 1870, and exploration activity was largely completed prior to 1900. Loughlin (Butler, et al., p. 439) completed a brief study of the area about 1913, and reported on the history and production as follows:

"No satisfactory account of the production of the West Tintic district can be given, for in the earlier years its output was included by the Director of the Mint



with the Tintic district. The Scotia Mine has been undoubtedly the largest producer, but accurate data of its output are not available. According to S. W. Riter, of Salt Lake City, who was one of its original owners, the first pocket of ore, found about 1870, amounted to about 250 tons of 65 percent lead ore containing a moderate proportion of silver. This ore was shipped to Swansea, Wales, and to smelters south of Salt Lake City. In 1871 the property was sold to Joab Lawrence and associates, who joined in building the Homansville smelter in the Tintic district. This enterprise failed, and the smelter was moved away in 1872. The mine later passed into the hands of the Boston-Tintic Mining Co., by whom it has been worked or leased intermittantly. The production of the Scotia Mine since 1880 has probably amounted to somewhat more than 3,000 tons, valued at about \$150,000.

From 1902 to 1913 only two mines shipped ore, both in small amounts."

Most of the mines in the district were abandoned by the time of Loughlin's study. The Scotia mine continued sporadic production under different leases until 1951.

In 1940 scheelite was discovered in the vicinity of the Tintic Western mine. The property was leased by the Desert Tungsten Company, who shipped 4,500 tons of scheelite ore averaging .9 percent  $WO_3$  from the Desert Tungsten mine in 1941-1944 (Jim Quigley, 1957, personal communication). The Desert Tungsten and other tungsten properties were trenched drilled, sampled, and mapped by the U. S. Bureau of Mines in 1942-1943 (Wilson, 1950, pp. 2, 6).

Several hundred tons of magnetite were shipped to the Tooele smelter for use as flux from the Iron King mine in 1946 (Jim Quigley, 1958, written communication).

Centennial Development Company, of Eureka, and Newmont Mining Company, of New York, did some exploratory drilling in

sec. 32, T. 11 S., R. 5 W. in 1952. Attempts to obtain information from Newmont were unsuccessful. Thus, the results of this exploration are unknown, but were apparently unsatisfactory because Newmont has shown no further interest in the area.

According to Quigley (1957, personal communication), Cerro De Pasco Corp. of New York mapped portions of the West Tintic Range and mining district in 1955, and conducted exploratory drilling for porphyry copper in the West Tintic monzonite in 1956. A later(?) barren granite was found to underlie the monzonite at a relatively shallow depth, and the drilling sample assays ranged from zero to only a few tenths of a percent in copper (F. N. Spencer, 1958, written communication).

No exploration or other activity was in progress in the West Tintic district during this (1955-1957) investigation.

The entire value of the ore produced has been estimated at about \$500,000 from the Scotia workings, and less than \$50,000 from the rest of the properties combined (Jim Quigley, 1958, written communication).

### Ore Deposits

The ore deposits in the West Tintic district have been described by Loughlin (Butler, et al., 1920, pp. 439-443), who describes them as:

"---compris(ing) several types, transitional into one another which indicate deposition at temperatures ranging from those existing along the margins of crystallizing intrusive rocks down to moderate and even low. All types are in limestone, in or closely associated with fissures, some of which coincide with the bedding of the rock.

"The deposits formed at highest temperatures are of the contact-metamorphic type. More or less contact metamorphism has been produced around all the large ore bodies of granodioritic and monzonitic sills. The most intense metamorphic effect is just south of the monzonite stock in the southwest part of the limestone area, ---"

Loughlin included a summary description of the ore deposits in each mine described in his report, and classified most of them as contact metamorphic or replacement types.

The mineral deposits of the district were classified by Stringham (1942, pp. 281-285) as pyrometasomatic veins, mesothermal veins and replacements, and quartz-barite deposits. Wilson (1950, p. 2), reported that the scheelite deposits on the Desert Tungsten properties occur in limestone areas adjacent to intrusive monzonite. Wilson considered the ore bodies to be pyrometasomatic in origin, but to consist of two types; (1) a series of veins occupying fault zones in limestone, and (2) tactite bodies adjacent to the limestone.

Ore deposition of the West Tintic mining district was probably associated with the earlier monzonite and later granite intrusive phases.

For a more complete description of the ore deposits in the West Tintic district, the reader is referred to the reports of Loughlin (Butler, et al., 1920, pp. 439-443), Stringham (1942, pp. 281-285), and Wilson (1951, pp. 1-6).

## Mines

Most of the mine workings were not accessible when Loughlin examined the district in 1913, but he (Butler, et al., 1920, pp. 439-443) described the workings and ore deposits for the following listed mines:

- Iron King mine
- Virginia Lode
- War Eagle claims
- Orient workings
- "1903" or "1888" mine
- Allah prospect
- Scotia mine

All of these mines, except the Virginia Lode, were located and placed on the geologic map along with the larger prospects and more recent mines listed as follows:

- Oro Plata mine
- Desert Tungsten mine (formerly Tintic Western)
- Pyramid mine

The Oro Plata mine is in the northwest corner of the area of exposed Paleozoic rocks, and consists of a vertical shaft in a small granite intrusion. Lamprophyre(?) occurs near the collar and on the dump, but ore-bearing rock was not present. The Pyramid mine is in the Pinyon Peak limestone just southwest of the large Tintic(?) quartzite klippe in the eastern part of the district. Malachite and limonite stain much of the material dumped near the collar.

The Desert Tungsten property consists of two vertical shafts (Wilson, 1950, p. 5), the 70-foot Bates shaft and the 400-foot Sullivan shaft, which give access to the underground

workings. Wilson presents maps and descriptions of the workings and ore deposits in his report, to which the reader is referred.

## THE BLUE BELLS MINING DISTRICT

### Location

The Blue Bells mining district is on the east flank of the Sheeprock Range, and lies north of the Tooele-Juab County boundary. It extends eastward from the crest of the Sheeprock Range to include all of Little Valley, and crosses Vernon Creek to include the "Iron" Mine, and a large prospect adit just north of the mouth of Little Valley. The district is easily accessible in dry weather by the Vernon Creek Road and the Little Valley Road, which extends west past the Little Valley Ranger Station to the Blackhawk workings.

### History and Production

The Blue Bells mining district was organized in 1896, and known production since that time has been small and sporadic. The early mining properties were taken up by R. E. Plough. These properties are often termed the R.E.P. properties in the Minerals Yearbook, and include the Morgan and Blackhawk workings. According to Heikes (Butler, et al., 1920, p. 430), the total known production to 1917 was 249 short tons of ore, which yielded 4,945 ounces of silver, 5.14 ounces of gold, and



284,557 pounds of lead with a total value of \$16,015. Since 1917, the properties have changed hands several times, the Morgan workings have been abandoned, and a Mr. Collett now owns the Blackhawk properties, which he has alternately worked and leased out for many years. According to Collett (1957, personal communication), over \$25,000 worth of high-grade silver and lead ore have been extracted from the Blackhawk properties since 1950. Collett also reported that \$60,000 worth of ore was taken from a single rich pocket many years ago. If these statements are accurate, the Blackhawk and Scotia workings are the only properties in the whole West Tintic area which have operated at a profit.

#### Ore Deposits

The only igneous rock in the Blue Bells district is the Precambrian diabase, which is called a "porphyry" by the local miners. The diabase apparently influenced the localizing of the ore, for all the deposits in the Little Valley area are in its vicinity. The diabase may have acted as a relatively incompetent rock during Laramide folding and thrusting, and the quartzite above and below was fractured and broken, forming conduits and voids for hypogene solutions to enter and deposit ore minerals. The mineralization is related to either the older West Tintic monzonite or the later granite intrusion.

## Mines

The Morgan Mine.--The old Morgan workings are just west of the mapped area near the crest of the Sheeprock Range at the head of Little Valley. Access is by climbing the first ridge north of the terminus of the Little Valley Road. The workings consist of an inclined shaft and two adits which follow mineralized fissures. The ore is brecciated quartz cemented with a mixture of galena partly altered to cerussite. Heikes (Butler, et al., 1920, p. 431) found quartz, some barite, and  $MnO_2$  to be the gangue minerals.

The Blackhawk properties.--The Blackhawk workings are in Little Valley a mile east of the base of the main Sheeprock Range, and are easily distinguished by the brown-weathering resistant quartzite ridge in the vicinity. The lower quartzite and diabase of the Sheeprock series has been thrust over tillite in the Blackhawk area. The main shaft follows a quartzite breccia zone and the ore is a quartzite breccia cemented by galena partly altered to cerussite. The present operators of the properties claim a silver content as high as 50 ounces per ton for some of the hand picked ores.

The Hidden Splendor Mine.--The Hidden Splendor workings are at the end of the Little Valley Road in a canyon a mile southwest of the Blackhawk properties. The mine consists of an abandoned, caved adit driven into the southeastern side of the canyon

along the contact of the diabase and quartzite. Ore samples found on the dump consist of a partially propylitized and altered gouge-breccia, with some disseminated galena. Little is known of the Hidden Splendor, except that it was promoted in the late 1920's, and apparently produced no ore worthy of shipping.

The "Iron" Mine.--The "Iron" Mine is east of Vernon Creek about two miles south of the Little Valley-Vernon Creek junction. It is readily seen from the road because of the red-brown color of the dump and the caved portal. The adit is driven north along a fault zone filled with a gougy limonite-hematite alteration of fractured dolomite. The fault dips steeply eastward, and black jasperoid occurs in the hanging wall some distance to the east. A transverse fault at the portal contains a three- to four-foot zone of halloysite and altered gouge. There is no known production of ore from the "Iron" Mine, and its value as an iron deposit is negligible owing to the relatively small reserves and transportation distance. However, the occurrence of halloysite is worthy of further attention.

The prospect north of the mouth of Little Valley.--The portal and dump of a large prospect adit is about 300 yards north of the Little Valley-Vernon Creek junction. The adit is driven westward along a fault in the upper phyllitic-shales. The

rock on the dump consists of shale, gray gouge, and some pyritized shale. No ore minerals were present.

### THE JASPEROID PROBLEM

The rather widespread occurrence of jasperoid in the bedrock exposures of the East Tintic and Oquirrh Ranges is often known to be associated with ore, or actually to be an ore in these areas. No ores or ore associations have been reported or observed in connection with jasperoid in the West Tintic Range, excepting one piece of silver-bearing float. Lindgren (1919, pp. 156-157) believed that there were two periods of silicification in the East Tintic district, and that both were associated with ore. However, Howd (1957, p. 126) points out that subsequent studies have shown that much of the jasperoid cropping out at the surface is not associated with ore.

The jasperoid problem is one of relating the occurrence of jasperoid, either barren or mineralized, to possible ore deposits at depth. If the main masses of jasperoid in the vicinity of faults, fissures, and brecciated zones are hypogene in origin, as most students of silicification believe, it is probable that some means of using the jasperoid as a guide to ore may be devised. Petrographic, geochemical, and spectrographic analysis of many samples of jasperoid associated with both ore-bearing and barren rocks, may provide a clue to its

use as a guide to ore deposits at depth. Howd (1957, p. 132) discussed a possible method of differentiating between barren and productive jasperoids as a result of the study of a large number of jasperoid thin sections from the Jenny Lind Tract in the Tintic mining district:

"Point values were assigned to textural and compositional properties and these point values were totaled for each thin section. The average total for jasperoids associated with known ore bodies is a positive value, but for barren jasperoids of the Jenny Line Tract the average is a negative value. There are enough exceptions in the correlations to prevent a definite statement regarding the relation to productivity of any given jasperoid. However, the results are encouraging enough to enable Bear Creek to be more interested in jasperoids with a high positive value than those with a strong negative value, and where other factors such as structure, lithology, and additional hydrothermal alteration are favorable, a jasperoid with a high positive total may be an excellent guide to ore."

Many jasperoid samples were collected during the present study for analysis by Bear Creek Mining Company, but the results are not yet known. Geologic conditions similar to those in the East Tintic Range are present in the West Tintic Range, excepting the crystalline igneous rocks may be at greater depth; thus, ore deposits similar to those of the East Tintic Range may be present, and, if so, the jasperoids may be the key to their discovery.

#### NONMETALLIC MINERALS AND MATERIALS

The only known production of nonmetallic minerals from the West Tintic Range came from the calcite pits east of Vernon.



These pits were operated about thirty years ago by a man named Lando Munding of Eureka, Utah. The rock was supposed to be dolomitic, and was shipped to sugar factories for use in the sugar-making process (Jim Quigley, 1958, written communication).

Halloysite occurs at the portal of the "Iron" Mine, and is a valuable clay mineral having numerous economic applications in industry. This deposit is not commercial in size, but is worthy of further investigation.

Commercial sand and gravel deposits in the area are absent. The pediment gravels contain argillaceous material, and, even after fluvial reworking, constitute a coarse and unsorted aggregate. The sands present in the lower portion of the Cherry Creek and Vernon Creek drainage systems are rather fine-grained and contain a very high proportion of argillaceous material.

The tuff, pumicite, and bentonitic material found in the Salt Lake formation within the area of investigation may in the future have some application for filter and building materials.

## GROUND AND SURFACE WATER

### General Statement

Three perennial streams, Vernon Creek, Cherry Creek, and Little Valley Creek are supplied by springs. Considering the

area and elevation of the Sheeprock-West Tintic Range, the maintenance of stream flow from the area is remarkable, and large ground-water reservoirs must be present to permit seepage throughout the year.

#### Cherry Creek Drainage Area

Cherry Creek heads at Cherry Creek Springs less than a mile north of Cherry Creek Reservoir. The springs never ceased to flow during the time of the field study. Other springs located just east of Cherry Creek Reservoir contribute more than 50 percent of the flow of Cherry Creek below the reservoir. The Cherry Creek Springs are considered to be fed from fissures, joints, and leached cavities in solid rock. It is possible, also, that groundwater moves into the Cherry Creek drainage along fractured and leached thrust imbrications, for it is difficult to visualize the small drainage area of Cherry Creek catching enough precipitation to supply the present flow.

Several small springs originate in the rocks east of Cherry Creek, but the water sinks before moving far. Other springs and small reservoirs are in the bottom of the west branch of Cherry Creek in the vicinity of Hassel's Ranch. The west branch, however, carries water only during storm periods.

Indian Springs, near the southwest corner of the mapped area, is a swampy, willow-grown area west of Cherry Creek.

## Vernon Creek Drainage Area

The drainage area of Vernon Creek is much larger than that of Cherry Creek and includes all of Horse, McIntyre, and Little Valleys. Information from local inhabitants indicates that Vernon Creek once rose from springs at the site of Dry Ranch. The perennial flow now begins from a spring in the tillite about a mile south of the junction with Little Valley Creek. Most of the waters of Vernon Creek are acquired from Little Valley Creek, which constitutes a smaller but more prolific part of the Vernon Creek drainage area.

Chokecherry Springs and other springs flowing from jointed tillite supply Little Valley Creek. The water presumably moves along a thrust plane near the base of the tillite, and is stored in its fractured quartzite members. Semi-consolidated colluvium and gravels in Little Valley may also store groundwater.

Methods of conserving the waters of Vernon Creek to increase the late summer flow were discussed with several of the local inhabitants. Vernon Creek has eroded a deep and sinuous channel in the alluvium of its valley for more than a mile north of the Little Valley junction, and a series of small dams across this channel were suggested to increase bank storage and thus provide a greater reserve for the dry season.

## Drainage East of the West Tintic Divide

East and southeast of Sabe Peak, Sabina Creek maintains a perennial flow for a short distance. Effluent seepage of water stored in the pediment gravels takes place where Sabina Creek has cut down to the impervious kaolinized rhyolite underlying the gravels.

The springs supplying the partial perennial flow of Devils and Death Creeks represent effluent seepage from water above the impervious Chiulos shale. Similar conditions occur at the head of North and South Spring Washes. Springs are known to flow from fissures in the southern andesite exposures, and seeps were observed near many of the thrust contacts on top of the Chiulos shale in the extreme southern exposures of the West Tintic Range.

Mud Springs, in the southeast portion of the mapped area, is thought to issue from the intersection of a drainage depression and an impervious bentonitic layer in the Salt Lake formation.

## ECONOMIC POTENTIAL OF THE AREA

The history of production of minerals from the area of investigation is not particularly encouraging. The present investigation has disclosed no potential new ore bodies based on the evidence of surface features. Any future

development of possible ore bodies at depth will be largely based on a study of hydrothermal alteration in the area. If the problem of jasperoid as an ore guide can be worked out, and the analysis of West Tintic jasperoids have favorable results-- it is possible that deep drilling would disclose "Tintic-type" base metal deposits in silicified carbonates at depth.

However, the cost of such an exploration program, would have to be justified by a more favorable economic position for base metals than exists at this writing (1958).

Limited production of silver from the Blackhawk properties should continue for many years. The quartzite breccia-dabase association appears to be part of a thrust imbrication that could extend far underground and contain a large ore body. In view of the association of the ore cemented breccia with the upper and lower contacts of the diabase, the careful study and prospecting of these contacts in the Sheeprock Range would seem justified.

With respect to nonmetallic minerals, it is likely that the bentonitic strata of the Salt Lake formation in the southwestern portion of the area are worthy of study.



SUMMARY OF CONCLUSIONS

The study of the stratigraphy and interpretation of the structural relations of the sedimentary strata and igneous rocks, as depicted on the geologic map of the area investigated, has led to certain justifiable conclusions.

The Sheeprock series and Mutual(?) formation represent deposition along the eastern borders of the Beltian geosyncline, and have great similarity of lithology and conditions of deposition to the Missoula group of upper Beltian age in the type area of western Montana. Tentative fossil evidence found in the Pinyon Peak formation supports the placing of the Devonian-Mississippian contact in the upper part of this formation as it is in the East Tintic area (Morris, 1957, p. 13). The presence of andesite flows in Green River strata along with the discovery of an eroded granite surface below the andesites provide a means of dating the extrusive and intrusive rocks. The intrusive rocks appear to be much older than previously thought, and the Green River strata in the West Tintic area represents the westernmost occurrence of this formation yet discovered.

The dominant structural feature is the Sheeprock thrust system of probable Laramide origin, but the Cedar Hills orogeny of Early Cretaceous age is believed responsible for uplift and pre-thrust(?) folding. Erosion of the Cretaceous uplift may be responsible for removal of Permian and Mesozoic

strata from the area during pre-Laramide Cretaceous time.

Block faulting and relatively gentle folding in Late Tertiary time began to shape the terrain as it is at present.

The mineral potential of the West Tintic area is not impressive, but base metal ores may lie at depth in the central portion of the West Tintic Range. If altered rocks, such as jasperoid, may be used as a guide to ore, and can be related to possible ore deposits at depth, an exploration program would be justified.

Further attention should be paid the Green River strata and associated extrusives. Such work could disclose an abundant fauna and provide more precise dating information. A detailed study of rock alteration and large scale mapping of the West Tintic mining district might disclose evidence for structurally localized ore bodies. Such detailed studies would add much to the knowledge of the area.

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# APPENDIX A

The partial Paleozoic section measured by Gardner (1954, pp. 17-19) in the West Tintic district follows:

The following section was measured eastward, stratigraphically upward, from the upper contact of the Eureka (Swan Peak) quartzite, and includes all formations younger than the Eureka (Swan Peak) quartzite in the West Tintic mining district.

	Feet
1. Limestone-bleached white, granular, re-crystallized, contains pink to orange weathering chert.....	55
2. Dolomite-dark gray, weathers light blue-gray, some bleaching.....	30
3. Limestone-bleached white, granular, re-crystallized, with portions of dark gray dolomite which have not been thoroughly bleached, tremolite in dolomite, some dolomite breccia bleaching decreases upward.....	210
4. Dolomite-dark gray, weathering light blue-gray, with numerous breccia zones, some bleached zones, beds of black dolomite prominent in last 80 feet.....	155
5. Dolomite-same as No. 4, with dolomite extremely brecciated, and with some chert...	100
6. Dolomite-dark gray, weathering light blue-gray, much dolomite breccia.....	130
7. Dolomite-dark gray, weathering black, medium-grained, laminated with thin streaks of gray coarse-grained dolomite.....	40
8. Dolomite-dark gray, weathering light gray, medium-grained, large portion covered, dolomite breccia in float.....	160

9. Dolomite-dark gray, weathering light gray, fine-grained, laminated, thin chert beds and some dolomite breccia.....	175
10. Dolomite-alternating blue-gray weathering and black laminated beds, which resemble "curly beds" where folded, beds about 1' thick, some dolomite breccia, branching structures in black dolomite, some chert....	225
Fish Haven-Laketown Contact?	1280
11. Chert zone-contains horn corals and chert bed 10' thick.....	55
12. Dolomite-medium gray, weathering light gray, with <u>Halysites</u> sp. and semi-globose forms of brachiopods in float (fossil outcrop not located).....	30
13. Dolomite-medium gray, weathering light gray, fine-grained.....	110
14. Dolomite-dark gray, weathering light gray, cherty.....	60
15. Dolomite-bleached white, granular, soft.....	40
16. Dolomite- dark gray, weathering light gray, chert, some dolomite and chert breccia.....	205
17. Dolomite-medium gray, weathering light gray, with many bleached zones.....	235
18. Dolomite-medium gray, weathering light gray, becoming cherty.....	210
Laketown-Sevy Contact	945
19. Limestone-medium gray, weathering light gray to cream color, some platy beds (4" to 10" thick) small amount of pink chert parallel bedding, very fine-grained with conchoidal fracture.....	300
20. Covered-Scotia Gulch.....	300
21. Limestone-light gray dolomitic, mostly bleached white, some blue gray weathered dolomite, becoming more prominent upward....	100
Sevy-Simonson Contact	700

22. Dolomite-dark gray, weathering blue gray and black, medium-grained, black laminated beds 2' thick, becoming more prominent upward. Some limestone beds..... 300
23. Same as No. 22, with chert beds and cherty dolomitic limestone, Cladopora sp. at top of unit in zone about 10' thick..... 130
- Simonson-Guilmette Contact 430
24. Dolomite-light blue gray, calcareous bleached white in many zones, some very cherty zones, Cladopora sp. 35' from top of unit..... 275
25. Quartzite-fine to coarse-grained, white to very light gray, prominent bedding, some cross-bedding, highly fractured (Allah (Victoria) quartzite)..... 50
26. Limestone-light gray, weathering light blue gray, platy with irregular thin white calcite banding parallel bedding, becoming cherty and dolomitic upward..... 60
27. Dolomite-dark gray, bleached, with inter-bedded limestone beds 1' thick, some cherty beds, and poorly preserved horn corals..... 250
- Outcrops mostly covered by alluvium 635